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METABOLIC MECHANISM IN BERIBERI[1]

By WM. D. FLEMING

Captain, Medical Corps, United States Army;
United States Army Medical Department Research Board

The bulk of the work, other than purely clinical, published on beriberi has dealt largely with anatomical findings, gross or microscopical. On functional disturbances one finds a meager literature, reporting results often widely varying, and conclusions from these results in many cases radically opposed. De Langen and Schut(5) found evidence of a lowering of blood lipoids. Jansen and Mangkoewinoto,(9) investigating the respiratory quotient of birds fed upon polished rice until polyneuritis developed, found an occasional fall in the respiratory quotient but this fall was not constant and could not be accepted as a criterion of the condition. Anderson and Kulp(1) found no change in the respiratory quotient of chickens in vitamine B starvation. This is corroborated by work recently reported by Mattill(10) indicating that deprivation of vitamine B does not interfere with glucose combustion. Hopkins(8) and Renshaw(12) found that vitamines apparently aided the use of sources of energy in metabolism.

The opportunity has recently been afforded the writer of examining the question of the respiratory metabolism in human subjects suffering from beriberi. An investigation of this disease as it occurred in the wards of the Philippine General Hospital, Manila, was undertaken by a committee of the staff

[1] From the laboratory of the United States Army Medical Department Research Board, Bureau of Science, Manila, P. I. Received for publication April 19, 1923.

of the Philippine General Hospital operating with the United States Army Medical Department Research Board. The patients examined were those in whom the diagnosis of beriberi had been made by this committee as a whole. The work done consisted in the determination of the basal metabolic rate, the urinary nitrogen, the respiratory quotient both for total combustion and for nonprotein combustion, and the fraction of the total heat derived from protein, fat, and carbohydrate, respectively. For these determinations the technic of Boothby and Sandiford(4) was followed, with estimation of nitrogen by the Folin micro-Kjeldahl method. In addition, determinations of blood sugar, nonprotein nitrogen, urea nitrogen, and creatinine were made by the system of Folin and Wu,(7) and of uric acid by the new method of Benedict.(3)

The data obtained are negative as pertaining to a definite pathological process in beriberi. However, the negative evidence is of interest as showing a metabolism essentially normal in a disease in which dietary factors loom so large. These factors are chiefly two: the lack of an essential element, the vitamine; and a very high carbohydrate content of the diet. Without discussing the question of how far vitamine deficiency can be considered an active factor in beriberi or taking up the question of infection as a causative agent, either direct or indirect in connection with the vitamine, two points may be noted. The first is that, unlike the experimental animals studied by Jansen and Mangkoewinoto, by Anderson and Kulp, and by Mattill, which were kept under a known vitamine deficiency, the patients studied in the present work, while in hospital, were kept on a diet rich in sources of vitamine B. The clinical symptoms of a polyneuritis may have been the residual result of a previous vitamine deficiency, this residuum being slow of regeneration, while the patients were, at the time studied, restored to a normal metabolism by the diet used in treatment. This possibility is realized. Against it the results of the work on animals by the investigators named must be cited.

Aub(2) and others have shown that the secretion of the suprarenal glands has a marked influence on the metabolic rate, raising this rate independently of action of the thyroid. This action, while appearing more quickly than that of the thyroid, is not so lasting. Since McCarrison(11) found hypertrophy of the suprarenals a prominent feature of beriberi, some expectation of an increased basal metabolic rate in these

beriberi patients was held. However, no evidence was found of any disturbance of metabolism as characteristic of beriberi, either in the level on which the metabolism was maintained or in the relative value of the sources of this metabolism. This absence of any shift in the usual proportion in which the respective sources of energy are utilized is interesting in the face of the high carbohydrate intake.

Table 1 gives the metabolism data for the beriberi patients and for a series of normal controls, the latter being convalescents in the surgical wards showing no symptoms of beriberi or of other conditions known to affect metabolism.

TABLE 1.—*Results of metabolism determinations.*

	Beriberi patients.	Surgical convalescents.
Basal metabolic rate----per cent--	—6.3	—5.3
Respiratory quotient	0.823	0.854
Nonprotein respiratory quotient	0.832	0.886
Total calories per hour	48.84	56.51
Calories from protein	10.39	11.59
Percentage of total calories from protein	19.2	20.8
Calories from fat	24.91	17.66
Percentage of total calories from fat	46.7	31.2
Calories from carbohydrate	18.59	26.77
Percentage of total calories from carbohydrate	34.1	48.1

Comparison of the results for these two groups brings out the following facts:

1. There is no significant difference in the basal metabolic rates of the two groups.

2. There is no significant difference in the respiratory quotients. Both quotients are indicative of a normal utilization of the food eaten.

3. In the percentages of the heat derived from the combustion of protein, fat, and carbohydrate, respectively, some differences are seen between the two groups. However, it is thought that these are variations between small groups rather than representatives of the particular group. Findlay(6) reported a reduction of glyoxalase in the liver of pigeons suffering from beriberi. While the percentage of heat derived from carbohydrate is less in the beriberi patients than in the normals it is still well within the limits of a normal metabolism and certainly cannot be taken as showing a definite breakdown in carbohydrate metabolism. Neither can any definite evidence be

found in this series of an abnormal utilization of protein or of fat.

In Table 2 are given the values found in the blood analyses of the two groups.

TABLE 2.—*Blood analyses.*

[All values are in milligrams per 100 cubic centimeters of blood.]

Group.	Cases.	Analyses.	Sugar.	Non-protein nitrogen.	Uric acid.	Urea nitrogen.	Urea.	Creatinine.
Beriberi with œdema	7	9	102	30.5	3.5	13.5	29.1	1.4
Beriberi without œdema	17	23	106	30.4	3.9	12.7	27.4	1.4
All beriberi cases	24	32	105	30.5	3.8	12.8	27.6	1.4
Normals	8	8	109	29.3	4.1	10.5	22.8	1.4

From the metabolic side two of these values, the blood sugar and the creatinine, are of especial interest. The blood sugar values confirm the evidence, discussed above, of a normal utilization of carbohydrate. Aside from the question of beriberi this is of interest as evidence against a diet high in carbohydrate, in itself predisposing to abnormalities of carbohydrate metabolism. It may be that the low total caloric value of the diet usual to the poorer Filipinos may be a factor of safety in this. Various workers have offered evidence that the full diet of the Jewish race in America is a factor in the high incidence of diabetes among that people. Here it must be remembered that the diet of the Jew is high in total caloric value rather than showing a decided preponderance of carbohydrate with a low total caloric value as obtains with the Filipino.

Viewing the creatinine values as an index of the endogenous metabolism, we find no difference between the two groups and a level in both slightly below that found in normal Americans, which is consistent with the minus basal metabolic rate found.

From the standpoint of damage to the excretory system in beriberi the blood analyses are valuable negative evidence, especially when the occurrence of œdema in this disease is remembered. Œdema was present in about one-third of the patients examined, but no differences were found referable to this symptom. In view of the actual presence of œdema in at least some of these patients when investigated, it is thought that the objection mentioned in the discussion of the metabolism, that the patients were then on a vitamine-rich diet, cannot apply here. The change of diet was of too recent institution to effect a recovery from any but slight and transitory damage

to the kidney. Nothing was found in the way of the marked increase in blood urea found by Yosikawa, Yano, and Nemoto (13) in some severe cases of beriberi.

SUMMARY

1. In a series of beriberi patients the basal metabolic rate was found to be the same as in normal controls. The respiratory quotients were normal. With the percentages of heat obtained from the combustion of protein, of fat, and of carbohydrate they point to a normal utilization of the food eaten. No evidence of the high carbohydrate intake as a disturbing factor was found.

2. Blood sugar values were against the high carbohydrate intake causing a "diabetic tendency."

3. No evidence was found of damage to the excretory power of the kidney in beriberi, either in patients with œdema or in those without this symptom.

BIBLIOGRAPHY

1. Anderson, R. J., and Kulp, W. L. Journ. Biol. Chem. 52 (1922) 69.
2. Aub, J. Journ. Am. Med. Assoc. 79 (1922) 95.
3. Benedict, S. R. Journ. Biol. Chem. 51 (1922) 187.
4. Boothby, W. M., and Sandiford, I. Laboratory Manual of the Technic of Basal Metabolic Rate Determination. Philadelphia (1920).
5. DeLangen, C. D., and Schut, H. Mede Burg. Geneesk. Dient in Nederl.-Indie, Deel 5 (1919) 81.
6. Findlay, G. M. Biochem. Journ. 15 (1921) 104.
7. Folin, O., and Wu, H. Journ. Biol. Chem. 38 (1919) 81 and 41 (1920) 367.
8. Hopkins, F. G. Journ. Physiol. 49 (1914–15) 425.
9. Jansen, B. C. P., and Mangkoewinoto, R. M. M. Mede. Gen. Lab. Weltevreden 3A (1920) 51.
10. Mattill, H. A. Proc. Am. Soc. Biol. Chem., Dec. 1922, in Journ. Biol. Chem. 55 (1923).
11. McCarrison, R. Ind. Journ. Med. Res. 6 (1918–19).
12. Renshaw, R. R. Am. Nat. 55 (1921) 73.
13. Yosikawa, I., Yano, K., and Nemoto, I. Arch. Int. Med. 20 (1917) 103.

THE DEVELOPMENT OF BAGUIO PLATEAU

A STUDY IN HISTORICAL GEOLOGY AND PHYSIOGRAPHY IN THE TROPICS

By Roy E. Dickerson

Honorary Curator, Department of Paleontology, California Academy of Science, Golden Gate Park, San Francisco, California

TWELVE PLATES AND SIX TEXT FIGURES

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INTRODUCTION

After several years spent in the study of Tertiary problems in the temperate regions of the Pacific Coast states of the United States, the writer has been much impressed with the differences in geologic and biologic processes of the Tropics as compared with similar processes in the temperate regions. Many times, during field work in the Philippines in the last three years, suggestions of these great differences were obtained in many connections. The exceedingly heavy rainfall over portions of the Archipelago and observations on results of these torrential

downpours [1] cause one to project these effects into the geologic past. In December, 1921, Mr. H. P. Whitmarsh, former governor of Benguet Subprovince, conducted Dr. W. D. Smith, Mr. G. B. Moody, and the writer to an interesting locality west of Baguio where an excellent and characteristic fauna of Vigo-Miocene age was obtained. Governor Whitmarsh had previously sent to the writer some excellent specimens of *Vicarya callosa* Jenkins, the finger post of the Miocene of the East Indian Archipelago, from one of these localities. With this evidence in hand an excellent geologic "datum plane of reference" was established in this region, and further data were secured which gave fairly definite evidence that Baguio Plateau had been developed by the wearing down of mountain systems, probably formed at the close of the Pliocene, to a gently rolling subdued topography which, in terms of Davis's geographic cycles, would be described as being of early old age. Not only was this surface apparently developed during the Pleistocene, but also it was hoisted to its present position, 1,250 to 1,500 meters (4,000 to 5,000 feet) above sea level during middle or late Pleistocene, faulted, and over much of the area of north-central Luzon eroded so completely that there are now but few isolated remnants of this once extensive low-lying country, which probably covered the central portion of northern Luzon during early Pleistocene. The deep erosion of Bued Cañon, Antamok Valley, and a large part of Agno River Gorge apparently has taken place during late Pleistocene and Recent times (Plates 1 and 2).

A great annual rainfall, alone, is not sufficient to cause this enormous erosion and the vast acceleration of geologic processes in this interesting locality; but the great rainfall delivered as torrential downpour, of intensity unknown in temperate regions, must be an important factor. This opinion is based upon observation in western Washington in the vicinity of the Olympic Mountains, the region of greatest rainfall in continental United States. This rainfall, however, while extremely large, is distributed over a considerable period of time, and a part of the precipitation during this time is not exceedingly heavy. The results are that the western slopes of the Olympic Mountains are covered with heavy forests of spruce, pine, hemlock, and cypress, with an exceedingly heavy undergrowth of tough shrubs with well-developed root systems. These root

[1] Annual average rainfall at Baguio, 4,598 millimeters.

systems are so extensive that the soil is firmly held in a perfect root mat, and erosion is consequently far less than one might think from a mere study of the amount of rainfall. Certain fair-sized streams in the coastal-plain region just north of Grays Harbor Bay have succeeded in digging only shallow valleys in the marine sediments of Pleistocene age, and but few of these streams have succeeded in trenching through the sands and gravels of this time to the underlying rocks.

From his previous experience the writer was quite unprepared to expect the conditions discovered in the vicinity of Baguio. The resemblance of the effects of tropical torrential downpour to that of arid and semiarid regions is noteworthy. The vast amount of débris deposited by such streams as the Agno and Bued as they debouch upon the central plain of Luzon is, after severe typhoons which swept across this region, reminiscent of cloud-burst effects in the Mohave Desert region of southern California. The writer hesitates to introduce a new variant into Davis's humid cycle, but the evidence compels him to conclude that quantity of rainfall is not sufficient to accelerate rapid development of topographic forms in humid tropical regions, but that the torrential character of great rainfall is the principal factor.

These general studies made in the environment of Baguio indicate that Luzon was visited by the same type of disastrous typhoons during Pleistocene age as continue to sweep across these islands at the present date.

REVIEW OF PREVIOUS WORK

Von Drasche[2] first made known the widespread occurrence of coralline limestone which is typically exposed at Trinidad, and he described the other rocks stratigraphically beneath this interesting formation.

> A short distance behind Kayan mighty breccias of doleritic rocks are encountered, then breccias of hornblende-sanidine trachyte, and farther eastward there appears a breccia-like rock bedded in thick layers [fig. 1]. The last-named consists of large and small irregular fragments of limestone and of a badly weathered trachytic rock. * * * This conglomerate alternates with strata of coralline limestone, very similar in every respect to that found in Benguet Province. The strata show an inclination to the southeast of 8°–12°.

Again he mentions this formation near Sagada.

[2] Von Drasche, R., Fragmente zu einer Geologie der Insel Luzon, Wien (1878) 36–46.

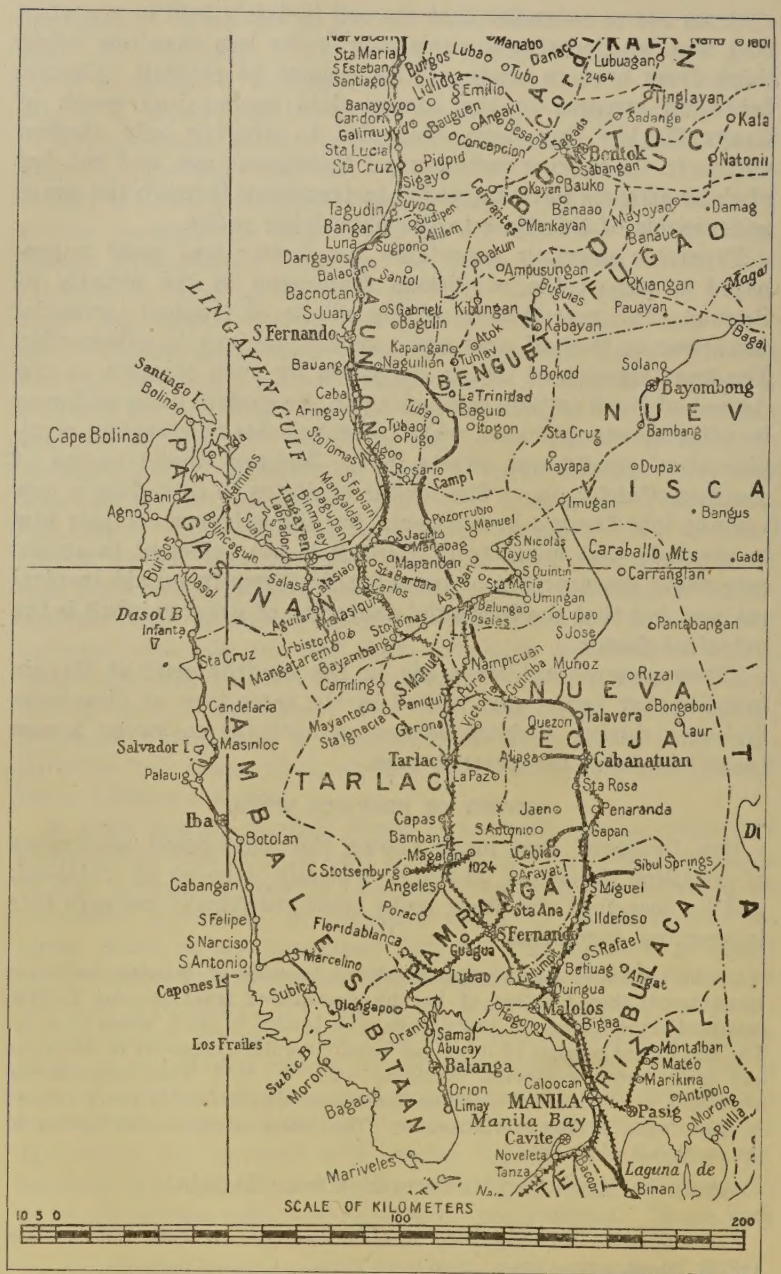

FIG. 1. Sketch map showing Baguio and a portion of central Luzon.

At Sagada extensive coralline limestone cliffs are again encountered. These may be traced south almost to Balugan and toward the north to Tetanan. * * * These coral reefs likewise show stratification with clearly discernible thick beds, usually with a southerly inclination of 15°–20°; between the strata I found a thin layer of greenish tuff.

He also mentions coralline limestone and tuff as an extensive mantling formation occurring in the vicinity of Lidlidda. Von Drasche discusses the age of this limestone as follows:

There can be no doubt that the coralline limestones belong to the most recent rocks occurring in northern Luzon. They always form the uppermost member of all formations, and with the exception of Benguet, where they are covered with a thin layer of red earth, I failed to find these limestones beneath other rocks.[1] * * * Even though it was impossible to give a reliable specific report on account of the poor state of preservation of the fossils, it nevertheless was possible for us [von Drasche and von Marenzeller] to declare with certainty that with the exception of one single piece which we could not identify, all of the rest belonged to genera which occur today in great abundance in the Indian Ocean, and even the individual corals can be referred without any question to living types. The corals examined do not show the least relationship to the Tertiary corals from Java described by Reuss.

Regarded from this point of view, the raised coral reefs of Luzon must be considered as very recent in origin. The genera identified by us are the following: *Galaxaea*, sp., *Favia*, sp., *Maendrina*, sp., *Porites* 2 sp. (?), *Astraeopora*, sp.

Von Drasche advances the view that Trinidad Valley represents a coral atoll. This hypothesis will be discussed later. The sequence of rocks established by von Drasche was—

(1) The coral reefs and breccias of coralline limestone with recent volcanic rocks; (2) the tuffs and tuff sandstones associated at places with coralline limestone beds and marls with plant remains; (3) recent eruptive rocks (quartz trachyte, sanidine hornblende-trachyte, hornblende-andesite, and dolerite); (4) the Agno beds, a mighty system of coarse sandstones and conglomerates which have been derived from the underlying diabase and aphanitic rocks; and (5) diorite, protogine gneiss, and chlorite schist.

A part of von Drasche's second group, as will be shown later, is the Vigo group unconformably beneath the coralline limestone and contains a coral fauna like the one described by Reuss from the Tertiary of Java. However, let this not be regarded as a carping criticism of the work of this hardy geological pioneer who first made known this interesting upland, and who amid privations of numerous kinds could still see

[1] This statement by von Drasche is modified by our present knowledge. The Baguio formation rests unconformably upon these Pliocene limestones.—R. E. D.

visions of the past through the well-trained eyes of the expert scientist.

The next worker in this field was A. J. Eveland, who contributed an excellent article upon the geology and mineral prospects in the Baguio region. Eveland published with this report a good reconnaissance map of the Benguet mineral regions, upon which are outlined the various geologic formations. Eveland recognized the peneplain character of Baguio Plateau and gives an excellent description of it. He says in part:[4]

> The Baguio Plateau is the most striking of the four physiographic types of the region. It is a peneplain of limited extent, with an average elevation of about 5,000 feet and with a drainage and topography so characteristic of a lowland region, that, viewed from a central point where the valleys of the Bued and Agno River drainage are not visible, it is hard to realize the situation of the area.

Eveland also recognized that Mount Santo Tomas was a block mountain upthrust above the plateau by movements along a fault bounding this mass on the northeast. In the same publication Smith discusses the petrography of the rocks of this region.[5]

Four years later Smith and Eddingfield[6] presented a revised map of the Baguio region, revised the geologic scale, and gave additional notes upon the economic geology of the region.

GEOLOGY

GENERAL STATEMENT

The oldest rocks exposed in the vicinity of Baguio occur in Antamok Valley (Plate 2). These rocks represent a portion of the basement complex of schists, diorites, slates, and cherts which form the backbone of most of the larger islands of the Philippine Archipelago. In Antamok Valley the basement complex is represented by a characteristic plutonic rock, a diorite. This diorite is technically described by Smith.[7] It seems possible that this diorite is intrusive in the slates and cherts of probable Jurassic age.

The next oldest rocks are the conglomerates, sandstones, and carbonaceous shales of Miocene age, and they are best seen in

[4] Philip. Journ. Sci. § A 2 (1907) 219.

[5] Smith, W. D., Petrography of some rocks from Benguet Province, Luzon, P. I., Philip. Journ. Sci. § A 2 (1907) 235.

[6] Smith, W. D., and Eddingfield, F. T., Additional notes on the economic geology of the Baguio mineral district, Philip. Journ. Sci. § A 6 (1911) 429.

[7] Philip. Journ. Sci. § A 2 (1907) 235.

the region about 6 kilometers west of Baguio, where they have yielded a typical Vigo fauna.

Two kilometers east of this place coralline limestones and conglomerates rest with probable unconformity upon the strata of Vigo age and upon andesite intrusive in the Vigo. These limestones upon the basis of their fauna have been correlated with the Malumbang formation, whose type locality is in Bondoc Peninsula, Tayabas Province, Luzon. Since their deposition they have been elevated, folded, and faulted.

Resting unconformably upon marly limestone phases of the Malumbang formation are the tuffs and breccias of the Baguio formation, which have been considerably faulted and folded. Across these various rocks, through the process of erosion in a tropical region, a low-lying plain dotted with well-rounded, low mountains was developed over the present site of central Luzon, and the streams of the early Pleistocene wandered indifferently across the folded and faulted tuffs and breccias of the Baguio formation as well as the folded Malumbang limestones and Vigo sandstones and shales (Plate 3). The last condition is well illustrated by Trinidad River, which was developed upon this plain and is now well intrenched in the vicinity of Trinidad. After the development of this surface, the whole region was elevated. The elevation was accompanied by some faulting, and movements along these lines of weakness have continued to the present time. The faulting is well shown by the raising of such great masses as Santo Tomas above the general level of the plateau. The faulting aided the enormous erosion of the typhoon season which has almost completely swept away the old Pleistocene surface from vast areas, leaving a region that is now at the typical stage of early maturity. Only the Baguio remnant exists in the near vicinity, but farther northeast, at Sagada, a similar plateau is reported, and a small residual is found at Pauai (Haight's place), 54 kilometers north of Baguio, and at Mount Data. Dr. W. D. Smith, who recently visited this noted mountain, describes it, in litt., as follows:

Mount Data.—Mount Data is a high block mountain (altitude, 2,650 meters, or 8,000 feet) made up almost entirely of beds of tuff and andesite agglomerate more or less in a horizontal position standing out very prominently in the landscape, marked on at least three sides by very imposing fault scarps. The topographic unconformity between this physiographic unit and that of the surrounding country is even more marked than in the case of the Baguio Plateau. The mountain has never been accurately mapped nor even roughly outlined. The accompanying diagram is an attempt to indicate its general shape and topography as sketched

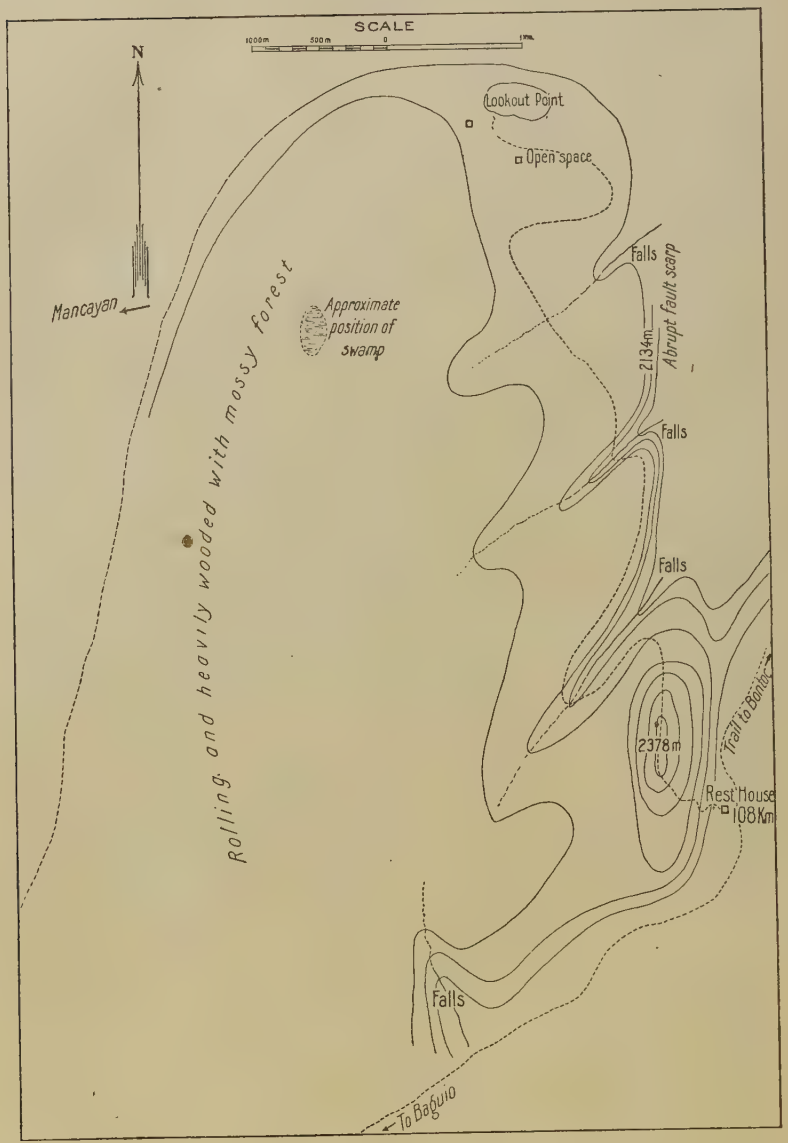

FIG. 2. Sketch map of Mount Data, Mountain Province, Luzon.

from the high point immediately back of the rest house at kilometer 108 (text fig. 2). The eastern escarpment is very imposing (Plate 4, fig. 1). It is at least 1,500 feet (450 meters) in height, with an average slope of about 60°. Over the side of this eastern wall plunge several considerable streams of water in wonderful cascades. One of these takes a total drop

of 500 meters in four or five plunges. In some places the walls are perpendicular. The surface of this plateau is very much like that at Haight's, Pauai, near kilometer 57, but owing to the heavy timber of the mossy-forest type it is difficult to make out the exact configuration of the surface (Plate 4). There is a fairly level area on the summit and in places in the rainy season standing water is to be noted and there is more or less swampy ground there. This has given rise to the tradition of a lake on top of Mount Data. At the time of my visit at the beginning of the rainy season I saw nothing which I could call a lake. Another point which has been exaggerated with reference to this mountain is the limestone on it. The only limestone that I saw on or about the mountain was a small residual patch of badly weathered limestone (Malumbang?) on the southeast slope very close to the Bontoc trail at an elevation of approximately 2,040 meters (6,800 feet).

At the extreme north end of this plateau there is a high rock from which the best panorama I have ever had in the Philippines is obtained. This rock is made up of agglomerate with a considerable amount of water-worn bowlders firmly cemented in an andesite matrix. There is no question in my mind that Mount Data is to be correlated with the Baguio Plateau.

Kilometer 81.—At about kilometer 81 on the Baguio north trail and 0.5 kilometer to the east of the trail there is a small plateau remnant with a remarkable "hanging valley" as shown in the accompanying photograph (Plate 4). The topography of this plateau remnant is distinctly old age or at least very mature, and at the south end there are a precipitous cliff and a large slide. In the upper portion of this slide there is an excellent section which shows one interesting feature; namely, an old buried soil about 1.5 meters thick, which at a distance has the appearance of a coal seam. A sample of this was obtained and proved to be merely a heavy deposit of humus. It is not even peat. There is about a meter of sand and tuff above this with the present soil on top.

Mancayan.—As you have suggested that the Mancayan region as shown on the old Bureau of Mines topographic map might also be a remnant of this old plateau, I studied it again, and I am in doubt about it. My opinion is that the Mancayan Plateau is not to be correlated with these other plateau remnants for the following reason: It seems to be an isolated topographic feature due to exceptionally hard quartz material, a part of which is covered by a trachyte flow. Its topography seems to me to be quite different from that of the other plateaus.

Sagada.—It has been suggested by some that Sagada is another plateau remnant. I have not visited this region since we have discussed this particular feature, but from my recollection of that country I am of the opinion that it does not correspond to the areas we have been discussing. There is a considerable bench near the Sagada Mission which is due to subsidence. However, there may be other areas in the vicinity of Sagada which I did not see.

River terraces.—As one travels north on the Baguio-Bontoc Trail particularly in looking across Agno Valley to the east several well-defined river terraces and elevated benches, at present far from the river, high on the sides of the Polis Range are distinctly visible. These undoubtedly are to be correlated with such terraces and benches as we have noted in Bued River Cañon near the Kias Trail and in the country to the northwest of Trinidad.

DIORITE

The best exposures of diorite in the Baguio region occur in Antamok Valley and vicinity (Plates 1 and 2). Iddings,[8] in describing a sample from Antamok Valley, says:

> At Antamok, Benguet Province, there is medium-grained quartz-diorite, with inequigranular consertal fabric. It consists of plagioclase and considerable brownish-green hornblende, anhedral with respect to each other, but euhedral toward quartz and orthoclase. There is some altered biotite. In places the orthoclase is intersertal to poikilitic, with inclusions of plagioclase and hornblende.

Diorites frequently associated with schists commonly compose a part of the basement complex upon which sedimentary rocks of the Vigo group of Miocene age were deposited. In many places fragments of diorite compose the sandstone of Vigo age and occasionally the sandstones are decidedly arkosic. The abundance of feldspar, hornblende, and quartz grains in the Vigo sandstones is in sharp contrast with their absence or rare occurrence in the sandstones of Malumbang Pliocene age.

VIGO GROUP, MIOCENE AND INTRUSIVES IN THE VIGO GROUP

Six kilometers west of Baguio City Hall and 400 meters south of the Naguilian Road at an elevation of 1,095 meters (3,650 feet, aneroid) a dark gray, argillaceous sandstone which weathers to a tan clayey sandstone occurs (Plate 2). Embedded in this sandstone are numerous specimens of *Vicarya callosa* Jenkins and coral fragments. The strike is approximately east and west, with a dip of 35° south. These sandstones without much doubt are unconformably below the Malumbang formation, as the dip is greater and the strike observations taken in the Vigo of this vicinity indicate that the Vigo group was faulted and folded along different axes than the gently inclined, westerly dipping limestones exposed along the Naguilian Road between kilometer posts 4 and 5. In this vicinity the dip in the coralline limestone, as Plate 5 clearly shows, is but 10°. The following species were collected at locality 40x:

Astreopora cf. *myriophthalma* Lamarck.
Fungia cf. *decipiens* (K. Martin).
Madrepora duncani Reuss.
Arca sp.
Dosinia sp.
Cerithium bandongensis K. Martin.
Conus sp.
Cypræa sp.
Natica sp.
Vicarya callosa Jenkins.

[8] Iddings, J. P., The petrography of some igneous rocks of the Philippines. Philip. Journ. Sci. § A 5 (1910) 169.

About 100 meters south of the fossil locality 40x, Mr. Graham B. Moody and Dr. W. D. Smith found andesite in a creek bank, elevation 900 meters (3,000 feet, aneroid). Mr. Moody stated that the andesite was in place and was probably instrusive in the Vigo. Since a residual of Malumbang limestone occurs at 1,065 meters (3,550 feet, aneroid) and possibly rests upon the andesitic dike, it seems quite probable that the andesite is of post-Vigo and pre-Malumbang age. Doctor Smith has kindly examined a thin section of this rock and described it as follows:

This is a badly weathered andesite consisting largely of glassy feldspars, sanidine, in a glassy groundmass in which one sees grains of magnetite, flakes of some ferromagnesian minerals, either pyroxene or hornblende. The feldspars even in the fresher-looking portions are somewhat decomposed, while in the outside portions of the specimen they are completely kaolinized, giving a whitish appearance to the rock. This rock would be classed in the older terminology as trachyte.

About one kilometer east of locality 40x, at a coal prospect made by Governor Whitmarsh's men, a black lignitic sandstone and a black lignitic shale with a strike of north 30° west and a dip of 40° west were noted. The intervening area was evidently sandstone and shale of the Vigo group.

In a creek at an elevation of 1,086 meters (3,620 feet, aneroid), 1.5 kilometers east of locality 40x, dark lignitic sandstone occurs in fault contact with a coarse conglomerate whose bowlders are composed of diorite and andesite. Thirty meters (100 feet) below, Mr. Moody obtained a dip of 30° south. Governor Whitmarsh found a large specimen of *Vicarya callosa* here, but when we visited the locality no fossils were obtained.

VIGO FAUNA

Another very interesting locality was discovered by Mr. James Wright, superintendent of the Trinidad Agricultural School, and Mr. Charles Mitchek, the foreman in charge of the stock farm. This locality is 200 meters north of the stock-farm buildings and was uncovered while they were attempting to develop water by an open cut in a small creek. The strata exposed in the small creek consist of coarse arkosic sandstone which in places is decidedly argillaceous. The structure in this vicinity is highly complicated by faulting. The strike is practically due north and south with a dip of 20° west. In the hills 0.8 kilometer east of this point, this arkosic sandstone is interbedded with tan tuffaceous marl exactly like the marl exposed in the intersection of the Naguilian and Campo Filipino Roads.

From this locality 200 meters north of the stock farm, 68x, the following fauna has been obtained:

Fungia sp.
Porites (?) sp.
Arca ferruginea Reeve.
Avicula sp.
Clementia papyracea Gray.
Cardium sp.
Dosinia lenticularis Sowerby.
Macoma sp.
Dentalium heptagonum Boettger.
Bullaria sp.
Cassidaria sp.
Cerithium javanum K. Martin.
Cerithium jenkinsi K. Martin.
Clavella sp.
Columbella bandongensis K. Martin.
Conus cf. *hardi* K. Martin.
Conus javanus K. Martin.
Mitra javana K. Martin.
Nassa cf. *costellaria* A. Adams.
Nassa crenulata Bruguiere.
Natica sp.
Nyctilochus (*Tritonium*) sp.
Sigaretus sp.
Strombus cf. *swainsoni* Reeve.
Vermetus javanus K. Martin.
Vicarya callosa Jenkins.

This fauna is clearly referable to the Vigo-Miocene.

LIMESTONE AND CONGLOMERATE OF MALUMBANG-PLIOCENE AGE

The most-prominent topographic features of the Baguio Plateau are connected with the erosion forms of the Malumbang coralline limestone, Mount Mirador, and Trinidad Valley. The best section for the study of this formation is found in the gorge of Trinidad Valley (Plate 5, figs. 1 and 3).

MALUMBANG FAUNA

The coralline limestone in this vicinity has yielded a fauna equivalent to that of the Malumbang formation of Pliocene age.

AREAL DISTRIBUTION OF MALUMBANG FORMATION

While in Baguio during December, 1920, Mr. John Reavis told Dr. Warren D. Smith and the writer of an interesting occurrence of fossils at his place, Klondike's Springs, in lower Bued River Cañon (Plate 6, fig. 1). On our way to Manila we investigated this locality; although the fossils found in the conglomerate were sparse, we succeeded in finding several fragments of coral rock which contained several species of coral.

These species are forms common in the Malumbang-Pliocene, and they represent either reworked Malumbang limestone after uplift and subsequent erosion or fragments broken off of coral reefs which lived in the Malumbang sea and were washed into a gravel beach that existed during Malumbang time. It is evident that many of the folded strata in Bued River Cañon are much younger than was previously thought and that the greatest possible age assignable for these conglomerates at Klondike's Springs is Malumbang-Pliocene. As suggested

above, these beds might be younger still. After much searching a species of *Pecten* was found in the sandy matrix of the conglomerate, so the conglomerate is thus proven to be marine. Both Doctor Smith and the writer regard these strata at Klondike's Springs as being of Malumbang-Pliocene age and as having been formed contemporaneously with Malumbang-Pliocene limestone; that is, as a pebble beach equivalent of a coral reef of Malumbang time rather than later deposits.

The strata at Klondike's Springs dip 25° west and strike north 38° west and are in the middle of a well-exposed section, excellently dissected by Bued River. At least 300 meters of conformable strata are above this locality, and apparently a minimum of 450 meters below it.

The Malumbang limestone has a much greater distribution than was previously recognized. The belt extending from a locality about 3 kilometers south of Mount Mirador to a point about 3.2 kilometers north of Trinidad Valley is the striking and well-known exposure. In a reconnaissance trip to the top of Mount Santo Tomas, Mr. Graham B. Moody, Mr. Palmer Beckwith, Dr. W. D. Smith, and the writer discovered several small blocks of Malumbang limestone. The tuffs of the Baguio formation were noticed at kilometer 5, but a short distance beyond and at kilometer 6, elevation 1,820 meters, aneroid, limestone was found. At locality 42x a fine specimen of *Leptoria* sp. was collected. A small collection of corals was made at 7.75 kilometers from Baguio, elevation 1,536 meters (5,120 feet). At locality 43x a branching coral, of a species that is common in the Malumbang formation, was collected. Between localities 42x and 44x the hill tops are composed of coralline limestone, but at 1,560 meters (5,200 feet), a short distance beyond locality 44x, an abrupt change in topography occurs; andesitic conglomerate is found, and the trail zigzags up a very steep face. This is caused by a comparatively recent fault at that point. Farther on, andesite is found at kilometer 11, elevation 1,950 meters (6,500 feet, aneroid); and a short distance beyond, about halfway between posts 11 and 12, coralline limestone again occurs, on top of the hill, locality 45x. From this point the trail descends slightly, and between posts 12 and 13 andesite again outcrops in a steep hillside. The contact between the last-named localities is marked by a fault (Plate 6, figs. 1 and 3). Resting upon the andesite is a considerable thickness of andesitic conglomerate. The slope then changes, and for a short distance the ascent is gradual. Suddenly, the

trail begins to zigzag, and another abrupt change occurs. No evidence of faulting was found except this sudden topographic change, but taken with the faults previously observed the writer regards the point of change as marking a fault. In this final steep climb to the top of Mount Santo Tomas andesitic agglomerate, andesite, and andesitic conglomerate were successively noted. The last-named member has a steep westerly dip of 78°. The andesite and andesitic conglomerate may be pre-Malumbang in age, and associated with the Vigo in part as intrusives. Practically the same types of andesite, andesitic agglomerates, and andesitic conglomerates are found on the east side of Bued River Cañon at the Copper King mine, now known as the Demonstration mine, where this material is probably in fault contact with a coarse sandstone of possible Vigo age, since pebbles of diorite, apparently derived from the basement complex of diorites and schists, were embedded in it.

At the foot of the Zigzag on the Baguio Road in Bued Cañon a dark gray to black limestone occurs (Plates 1, 2, and 7). This limestone yielded the following fauna:

Stylophora cf. *mordax* Dana.
Avicula sp.
Clementia papyracea Gray.
Mactra (?) sp.
Tellina sp. *a*.
Tellina sp. *b*.
Venus purpera Linnæus.

This fauna is referred to the Malumbang, and the dark color of the limestone is probably due to infiltering waters.

BAGUIO FORMATION

Andesitic tuffs and breccias of late Pliocene or early Pleistocene age which rest unconformably upon marl of the Malumbang formation are assigned to the Baguio formation of Smith. The writer does not limit this formation to that portion containing silicious-spring deposits, but regards the silicious-spring material as a later and adventitious deposit of no great importance from the point of view of the student of historical geology. This use of the term "Baguio formation" is much broader than that of Smith, who first used the name; but, since the city of Baguio is built upon these andesitic tuffs, agglomerates, and breccias, and these rocks are finely exposed here, the writer thinks best to extend the name. Eveland's reconnaissance map of the Baguio region shows the areal extent of this formation. The materials in this formation were practically all derived from a neighboring volcano or volcanoes, and apparently all were deposited upon land or in shallow lakes. Certain outcrops

of the andesitic tuff, notably the cut in Trinidad Road 0.5 kilometer north of Baguio City Hall, are well bedded and show considerable sorting, thus indicating that these deposits were probably laid down in a lake or in the low, flat valleys of that time. However, the road exposures near the Pines Hotel show another method of deposition. Here occur large angular and subangular fragments of a solid andesite embedded in finer tuffs. These deposits probably represent an agglomerate formed as a volcanic mud flow. The third notable phase is a very hard andesitic breccia composed of angular andesite fragments varying from 5 to 10 centimeters in greatest dimension.

STRATIGRAPHIC RELATIONS OF BAGUIO FORMATION TO VIGO AND MALUMBANG

The relations between the Malumbang formation, Vigo group, and the Baguio formation (as revised below) were obscure to Eveland and Smith, since at Trinidad, where the formations are well exposed, the contact is a fault. Also, the Malumbang-Baguio contact, 100 meters north of the provincial building at Trinidad, is likewise a fault. When the writer attempted to map a small area in the vicinity of Mount Mirador and Trinidad Valley in detail, it was evident at once that the Baguio formation rested with marked unconformity upon Malumbang limestone and the Vigo group. The small outliers of Baguio formation along the Mount Mirador Road and the road to Dominican Hill demonstrate this relation clearly. In tracing the contact between the Malumbang limestone and the Baguio formation on the west side of Trinidad Valley, the writer, accompanied by Mr. James Orbison, located several residuals of the Baguio formation resting upon unconformably Malumbang limestone (fig. 3). The nature of the contact near the alluvium of Trinidad Valley clearly demonstrates this relation, although a portion of the contact at a point 4.8 kilometers south of Trinidad is a small fault. The relations between the Baguio formation and the Vigo were discovered when Doctor Smith and the writer examined a fossil locality which was previously located as being in the tuff of the Baguio formation, but which proved upon reëxamination to be a marl member of the Vigo-Miocene. This marl member in the local field is associated with arkosic sandstone in the vicinity of Trinidad Farm School, where a characteristic Vigo fauna containing *Vicarya callosa* has been obtained. The marl member exposed along the Naguilian Road at Campo Filipino Road, 1 kilometer west of Baguio City Hall, yielded numerous casts of marine Pelecypoda

and Gastropoda where it is unconformably overlain by andesitic tuff, a member of the Baguio formation. The irregular, unconformable contact at this place is marked by the dark brown

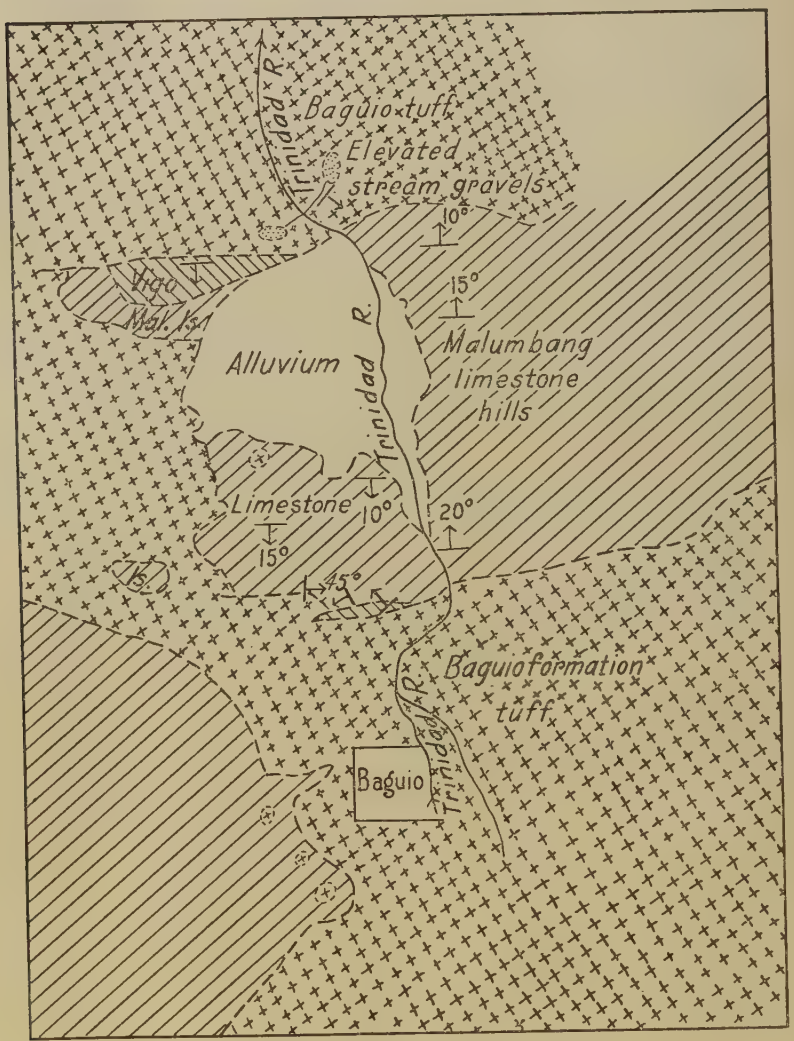

FIG. 3. Geologic sketch map of Baguio and vicinity.

soil resting upon yellow marine marl. Fragments of the tuff and agglomerate of the Baguio formation, in turn, rest upon and are embedded in this soil.

FAULTING AND LANDSLIDES IN THE BAGUIO FORMATION

The tuff members of the Baguio formation in and around Baguio do not exhibit any regularity in dip and strike, but vary greatly from place to place. These variations suggest many local minor faults, in addition to the well-marked contact faults mentioned above. These minor faults may be due in part to local slumping after the limestone beneath the Baguio formation had become cavernous. Doctor Smith has advanced the same hypothesis to account for the Hospital Hill slides. His statement, in litt., is as follows:

> The head of Bued River Cañon is marked by some very interesting landslides, which not only are producing some rather pronounced changes in the topography of that region but have also become of first importance since some Government public buildings have been endangered.
>
> Just before one reaches the Baguio Plateau proper traveling along the Benguet Road, one climbs to a bench that is largely due to subsidence of material from the valley sides. There is a broad amphitheaterlike area here 2 or 3 miles in length and a mile or so wide which remarkably simulates the cirquelike heads of glaciated streams. At the upper end of this valley there is a huge crack or series of cracks which run around these hills about as the "bergschrund" found at the head of glacial cirques does. On the west side of the Benguet Road the greatest slip can be easily studied. There is a fault here in loose tuff, sinter, and volcanic breccia amounting to at least 50 meters. The slip plane has an angle of from 55° to 60° and at this point trends north and south. In January, 1915, Mr. V. E. Lednicky, formerly of the Bureau of Science, was called upon to report upon the Hospital Hill slide. The writer visited this region during several seasons previous to that time, and during one of these visits, in the spring of 1914, he measured the subsidence, which then amounted to 35 feet, and the rate of movement, which at that time was 1 inch an hour. As this material is all very loose and only held together by clay, it is absolutely certain that there will be other slides behind the present one and the hospital buildings, unless moved, will ultimately be wrecked. [Plate 8, fig. 2.]
>
> This subsidence is due to several factors. Undoubtedly the saturation of these loose materials with water and the high angle of the valley walls, which are far above the angle of repose, are important causes, but the ultimate cause probably is the solution of limestones at the bottom of Bued River Cañon, notably at the foot of the Zigzag, which would permit of the leaching out of the rocks and thereby cause the slumping of the material from above.
>
> Similar and even greater slides occur much farther north in the Mountain Province. A notable one at Sagada extends over even a larger area, where the amount of subsidence in 1914 amounted to over 30 feet. The fault crack, following the periphery of the valley head, was when seen by the writer at least 2 miles long and a large Igorot village was gradually settling into the cañon without any particular disturbance of the inhabitants. Some time previously the Catholic church which

had been located, unknowingly, over the fault line was tipped over at a considerable angle and partially wrecked and had to be abandoned.

Many of the plateaulike areas in northern Luzon and especially many of the benches in the valleys are due in part to fill as a consequence of these enormous subsidences of the loose, saturated terrane. These slides will not cease until the angle of repose for that kind of material is reached.

The writer is in agreement with these views concerning the hospital slide, which were expressed in the field by Doctor Smith before the unconformity between the Baguio formation and the underlying Malumbang was discovered. Since the limestones at the foot of the Zigzag are now recognized as Malumbang-Pliocene, and not Eocene as was previously suggested, this hypothesis is still further strengthened.

FLORA

Science is greatly indebted to Father Francisco de P. Sanchez, of Ateneo de Manila, for his efforts and care in collecting paleontologic specimens in the vicinity of Baguio. Dr. W. D. Smith and the writer had the privilege of studying Father Sanchez's collections on exhibition in the museum on Mount Mirador, Baguio. Of particular interest in this collection was a flora obtained from the Baguio formation, from Government Center quarries, about 1.6 kilometers east of Mount Mirador. The following species were identified for Father Sanchez by Mr. E. D. Merrill, director of the Bureau of Science:

Vaccinium cumingianum Vidal.
Clethra lancifolia Turcz.
Machilus sp.
Elæocarpus argentea Merr.
Ardisia sp.

The specimens were obtained from the silicious facies of the Baguio tuffs and, according to Mr. Merrill, the species are essentially those of an upland flora (Plate 10, fig. 1).

PLEISTOCENE

STREAM GRAVELS

Prominent stream terraces, much dissected, occur in the middle course of Bued River. The coarse gravels of these terraces are in places 6 to 9 meters thick, and they rest with marked erosional unconformity upon the andesites and andesitic breccias in that part of the cañon 15 to 30 meters above the river. With little doubt, these terraces register a rest period in the general uplift of Pleistocene time, during which a fairly wide valley bottom was developed. The terraces may correspond to a vague secondary level in the upper Bued River region below the Ba-

guio Hospital. This region is so much altered by extensive landslides in the Baguio formation that a definite decision is unwarranted.

DEVELOPMENT OF BAGUIO PLATEAU

GENERAL STATEMENT

The abruptness with which Baguio Plateau first strikes even the casual tourist is a noteworthy incident, which is punctuated by the chauffeur's sudden shifting into high after a long steady grind in intermediate or low gear up the tortuous, steep grade of the Zigzag of the Bued River Road. (See Plate 8, fig. 1.) A feeling of relief from strain on the part of the "back seat drivers" is notable as well, since the chauffeur rounded many of the curves with but little to spare, and visions of an overturned car in the deep cañon below have appeared to the timid. In December the late evening air, filled with the healing odor of pines, has a snap to it quite reminiscent of the temperate homeland. The American takes a new lease on life and realizes that he is truly not in the Tropics. The papaya, the banana, the coconut palm, and the graceful festooned bamboo of the lowlands and the vine-entangled, thickly foliated tropical forest of Bued River Cañon are no longer a part of the scene, but an open pine forest with a grass carpet clothes the low, beautifully rounded hills and wide, gently sloping valleys of this land, which is truly a fairyland after a couple of years spent in the enervating humid heat of the Philippine lowlands. Only once before has the writer experienced such a striking contrast, and that was when he descended in three hours from a 2,040-meter (6,800-foot) elevation, the snow-covered edge of the Colorado Plateau, to the warm desert river 1,440 meters (4,800 feet) below on a day in late December. Both incidents were exhilarating and impressive, but the restfulness of Baguio Plateau imparted to the individual a feeling of security not felt in the Colorado Cañon, where the very plants and animals were fiercely struggling for existence in an arid surrounding, forbidding but grand.

The uniqueness of Baguio Plateau appears even greater after short excursions in the vicinity are taken. A walk out Bua Road to the plateau edge enables the geologically trained visitor to see even better the sharp contrast between the plateau and the deep eroded V-shaped gorges of Gold Creek and Antamok River. A further stroll to the hilltops of Pakdal thoroughly convinces him that these well-rounded hills belong with the Baguio Plateau and represent the uplands of this once low-lying country.

A tramp along Mount Santo Tomas Trail confirms this view, and from the upper elevations the hanging valley of Loacan is also recognized as an old wide stream valley robbed of its headwaters by some piratical tributary or tributaries of Gold Creek and left hanging on the wall of Bued River Cañon through a process of rapid erosion of the master stream (Plate 9, fig. 1, and Plate 10, fig. 2).

An automobile ride from Baguio to Trinidad with its astonishing variety of scenery, the gently rolling valley and hills, the sudden entrance into the narrow shelf-cut road of Trinidad River Cañon and the equally sudden appearance of Trinidad plain impress all with their pleasing contrasts. A walk from the capitol at Trinidad for a short distance along the Mountain Trail demonstrates the great differences between the Baguio Plateau and Trinidad Valley and the sharply chiseled ridges and acute V-shaped valleys of the country traversed by the Mountain Trail. Such are the temptations placed before the student of historical geology and physiography which cause him to dream and embolden him to attempt a reconstruction of the Past.

LOACAN VALLEY

From the Mount Santo Tomas Trail looking eastward, one sees the splendid hanging valley of Loacan with its wide, gently sweeping slopes, and pictures of a quiet-flowing stream in the middle of a wide shallow valley of the New England country come to mind. The last impression at once fades when, upon rounding another turn of the trail, the steep cañons of upper Bued River come into view, and one sees the wall over which the now feeble waters of Loacan Creek descend abruptly to join the waters of the present-day Bued River. A short automobile drive through Camp John Hay across the easily eroded tuffs of the Baguio formation brings us to this valley. The slopes are those of early old age, but the stream now occupying the valley center is very small. A view at the upper part of the present valley clearly indicates that the piratical Gold Creek has successfully beheaded this ancient stream. The trend of the present Loacan Valley indicates a consequent southwestward-flowing stream, and the recent movements along the stream course athwart Mount Santo Tomas fault may have been the cause of the rapid capture of its lower portion. This explanation is even more apparent when one considers the highly youthful character of upper Bued River during the descent of the Zigzag.

In connection with this major faulting, incidental movements along the east and west cross faults which cut the Santo Tomas Trail probably occurred as well. Now pour into these newly formed trenches torrential tropical rains and with exceeding quickness a deep cañon is developed. If this reasoning be correct, then this faulting must have taken place during the late Pleistocene and may have been incidental to the general uplift of Baguio Plateau. Since earthquakes are frequently reported at Baguio, it is highly probable that seismic disturbances still continue along these faults at the head of Bued River. The fact that the hanging valley of Loacan still remains further indicates a late Pleistocene age for these events, since hanging valleys, like lakes, are but transient physiographic features. Faulting may also have aided Gold Creek and Antamok River in beheading the Loacan, as a very prominent northerly trending fault occurs in Antamok Valley near the Benguet mine. This fault has brought the older diorites in contact with the late Miocene andesites.

TRINIDAD VALLEY

The most-striking feature seen on the topographic map of Baguio Plateau is the wide, round, sparsely contoured spot indicating Trinidad Valley. Not only is this true upon the map, but the intelligent nontechnical visitor to this valley sees the striking contrast between the narrow gorge of Trinidad Creek and the even valley floor beyond. At once he seeks an explanation, and the current hypothesis of volcanic crater develops as soon as the craterlike form is observed. It is not the writer's intention to waste too much time bowling over a "paper man," but a little explanation is due the layman. If a volcano were suddenly formed in an area of nearly horizontal sedimentary rocks then, with the upthrust, the sedimentary rocks would be inclined away from the center of the volcano on all sides, and the lavas or mud flows would be poured out across the broken edges of the sedimentary beds and form lava or mud-flow slopes completely burying the sedimentary beds for a time. Later dissection after the volcano became dormant would partially exhume the sedimentary beds and a concentric arrangement would be found due to the more easily eroded sedimentary beds. Such a case occurs in the center of the Sacramento Valley, California. The Marysville Buttes, "the stump of an old volcano," consist of a central core of a coarse-grained lava, andesite, which was forced up in the valley floor, a ring of marine sedimentary rocks

which were upturned when the lava was forced out, and a ring of andesitic mud flows on the edge of the sedimentary beds of Knoxville-Cretaceous, Chico-Cretaceous, and Tejon-Eocene ages occur as a series of smooth rounded hills forming an interrupted ring 1.6 kilometers or less in width, in striking contrast to the resistant core and the outer ring of firmly cemented mud flows which dip in all directions from the central core at angles of 4° or 5°. A glance at the geologic sketch map of this Trinidad area shows that four formations occur here; namely, alluvium, coralline limestone, andesitic tuff-breccia, and tan marls and associated arkosic sandstones (fig. 3). The alluvium occupies the round or valley portion. The south and east sides and portions of the north and west sides of the valley consist of coralline limestones and associated marine shales and sandstones. The dominant dip of these beds on the east side of the valley is 10° to 15° north. Only that portion of the valley out of which Trinidad River escapes is hard andesitic tuff-breccia (Plate 10, fig. 3). If a volcanic crater exposed sedimentary beds upon its walls, then the dominant dip would be away from the crater in all directions and lavas would be found resting upon such sedimentary beds. Such is not the case at Trinidad. Von Drasche regarded Trinidad Valley as a coral atoll, because coralline limestones border it. Interesting as this view would be, field evidence does not offer it much support. The presence of andesitic tuff-breccia on the north side in fault contact with coralline limestones, the prevailing north dip of the shales, sandstones, and coralline limestones on the entire east side of the valley, their much steeper dip than that of depositional coral-reef material, and the alternation of sandstones, shales, and limestones, are not characters of a coral atoll. Furthermore, the coralline limestone is too largely composed of rolled coral fragments, and no evidence was found to indicate that the corals were in place.

What then is the explanation of this most extraordinary, round, alluvium-covered valley surrounded on all sides by hills and steep-walled mountains? After a cursory study of the valley, the writer was early impressed with the fact that it was neither a volcanic crater nor an atoll, but was due to some peculiar erosional development. As outlined above, the sharp contrast upon entering and leaving this valley is striking, even to the casual visitor. Viewed from the hills above Trinidad, looking southward up the Trinidad Gorge and to the hills of Baguio in the distance, the terrace condition of the east portal of Tri-

nidad Water Gap is very evident and this elevation of 1,450 meters (4,850 feet) fits in nicely with the low-lying hills of Baguio beyond (Plate 11, figs. 1 to 3). When the stream cut this terrace at 1,450 meters (4,850 feet) the country evidently was at an elevation near sea level, and the course which the stream picked out across a country that was then largely covered by the tuffs and tuff-breccia of the Baguio formation and its alluvial derivatives was an accidental one. After uplift, the stream had sufficient volume to maintain its course and within its former wide valley now represented by the residual at 1,450 meters (4,850 feet) dug a cañon for itself. With uplift, the erosive power of the stream was greatly increased and this cañon was further developed. This downward cut of the stream may be likened to a band saw against which a board is thrust. As the saw descends through the board, a knot, soft dry-rotted spots, and wood of medium grain are successively encountered. A sharp narrow slot is cut into the knot, the saw may be bent from its course as it passes through the soft dry-rotted portion, while in the clear-grained wood a slot of moderate dimension is cut. Similar conditions, with differences in hardness, occur in the vicinity of Trinidad Valley. The andesitic tuff-breccia north of Trinidad corresponds to the knot. The compact, resistant coralline limestones of the water gap at the south entrance of Trinidad Valley represent another such development. The soft incoherent tuffs on the west side of Trinidad Valley are analogous to the soft dry rot in the timber. The unusually hard andesitic tuff-breccia north of Trinidad acted as a temporary dam, that is, in technical language, set up a local base level of erosion. The stream above this dam was at times temporarily restrained from downward cutting and then began to swing from side to side, developing broad meanders, now represented by somewhat distinct terraces on the side of Trinidad Valley. Since the softer material was on the western side and the harder material on the eastern, this horizontal cutting was chiefly confined to the western side.

Baguio Plateau was not elevated at one stage, since two terraces noticeable on the hills bordering Trinidad Valley represent in all probability two uplift stages. The third uplift is probably represented by the present valley development. As Trinidad River cuts through the north water gap again the dam will be lowered and in future geologic time Trinidad Valley will disappear. This explanation is chiefly physiographic, so direct geologic evidence of Pleistocene stream terraces containing

reworked material derived from the older formations was sought.

In company with Dr. Warren D. Smith, Trinidad Valley was studied in detail in the last two days of May, 1922, and conclusive proof concerning the development of this unique valley was obtained at this time. Reference to the geologic map of this vicinity brings out the fact that the western side of the valley is composed of the soft incoherent facies of the Baguio formation, in striking contrast to the compact and more-resistant limestones which are found on the eastern side of the valley (Plate 12, fig. 1). As was pointed out above, Trinidad River cuts directly across the compact, thoroughly indurated facies of the Baguio formation—a tuff-breccia. This tuff-breccia has a distinctly bedded appearance, with a strike about north 45° east and a dip of 15° southeast, in very evident contrast to the northerly dip of the coralline limestone on the east side of Trinidad Valley. Doctor Smith was skeptical concerning the writer's explanation of the development of the Trinidad River gorge north of the capitol of Benguet Subprovince at Trinidad, so that prominent hill with an elevation of 1,410 meters (4,700 feet) 1.2 kilometers north of Trinidad was investigated. On the east side of this hill at an elevation of 1,380 meters (4,600 feet) the writer obtained a good-sized piece of Malumbang-Pliocene limestone in bowlder form, and this evidence as representing Pleistocene stream gravel was accepted by Doctor Smith. The hill 0.4 kilometer northwest of Trinidad was next climbed, and again the writer succeeded in obtaining excellent fragments of limestone at 1,395 meters (4,650 feet) elevation. Upon climbing the hill 30 meters higher, at 1,425 meters (4,750 feet) elevation, Doctor Smith began finding fragments of well-rounded limestone, quartz, and andesite typical of the pre-Malumbang andesite, and was then convinced that Trinidad River was truly an antecedent stream intrenched in its present position, and that the stream gravels represented a Pleistocene formation resting unconformably upon the Baguio formation at these points.[9] After this discovery, Doctor Smith picked out two distinct terraces encircling the valley on the east, west, and south sides, which were approximately 60 and 90 meters (200 and 300 feet) above the valley floor, whose elevation is 1,320 meters (4,400 feet). In the afternoon Doctor Smith, Mr. James A. Wright, and Mr. Charles Mitchek visited

[9] The areas on the map representing this Pleistocene formation are considerably exaggerated in size.—R. E. D.

the Vigo-Miocene fossil locality which is located about 200 meters north of the stock-farm buildings. In this vicinity the gap between the drainage toward the China Sea and Trinidad Valley is exceedingly low, and both Doctor Smith and the writer were agreed that this gap had been lowered long after Trinidad River was firmly intrenched in its present course. The hard, resistant, andesitic tuff-breccia north of Trinidad has undoubtedly acted as a dam, creating at times a well-marked, local base level. This dam may have been renewed by faulting. The two terraces encirling Trinidad Valley probably represent substages in the general uplift of Baguio Plateau and the very notable plateau at Amsalsal and its correlative terrace 8 kilometers (5 miles) north are probably referable to one of these substages. The present floor of Trinidad Valley consists of thick alluvium which in the temporary marshlike area, now being drained through the energy of the farm-school management, is decidedly peaty. The writer interprets this marshy area, 0.4 kilometer southwest of Trinidad, as representing the abandoned channel of Trinidad River when that river had a course around the western side of the valley.

In summary, then, Trinidad Valley is neither an extinct crater nor an atoll but is a peculiar erosional development due to an antecedent stream which in its successive intrenchments exhumed the older formations. This valley gives additional confirmatory proof that the Baguio Plateau surface was developed at elevations probably varying from sea level to 360 or 450 meters (1,200 or 1,500 feet), since its development can be explained in no way except through general regional uplift.

MINOR MODIFICATIONS

Since the Baguio Plateau has been uplifted, minor modifications of its surface have occurred, but these changes are not sufficient to obliterate the record. The sources of Trinidad River are cut into the original surface for depths of 60 to 90 meters (200 to 300 feet). Besides these erosional changes some of the local subsidences, such as the pond near the Pines Hotel and the sink near Mount Mirador, are due to the solution of the underlying Malumbang limestone (Plate 12, fig. 3). Some of the local earthquakes at Baguio have been ascribed to this cause, and some of the minor shocks may be thus explained. The more likely explanation is that the heavier shocks are results of movements along the Recent and late Pleistocene faults, such as those of Mount Santo Tomas. Doubtless certain slides, rock falls, and incidental after-adjustments have exerted their influence upon Baguio Plateau in minor degrees.

EXTENT OF BAGUIO PLATEAU

The interesting work of Doctor Smith in the vicinity of Mount Data, which he has kindly permitted the writer to use in this paper, demonstrates that Baguio Plateau extended in a northerly direction for at least 120 kilometers. How much farther north it extended, future exploration may reveal. Concerning the southerly and easterly extent of Baguio Plateau no definite evidence is available, but from the researches in another field of science, that of botany, some idea may be gained.

THE PRESENT UPLAND FLORA OF BAGUIO PLATEAU AND BENGUET AND ITS DEVELOPMENT

The temperate-zone aspect of the trees and scenery of Baguio Plateau interest all Americans who visit this unique spot, and the origin of this flora stimulates scientific imagination. If it be truly a temperate flora, at what geologic time was it established and how was it maintained during the Pleistocene? Is it possible that the flora demonstrates that high mountains have been present in northern Luzon since the beginning of the Miocene? A really temperate flora could scarcely survive the warmth of the Philippine lowlands even of Pleistocene time. Such were the questions the writer brought to Mr. E. D. Merrill. In reply Mr. Merrill has written the following statement:

> The flora of the Benguet-Bontoc region, an area essentially characterized by the dominance of a species of pine, *Pinus insularis* Endl., is in striking contrast to that of other parts of the Philippines, presenting very numerous northern types that do not occur elsewhere in the Archipelago and indicating a derivation, so far as these northern types are concerned, from the central mountain mass of Asia, many of the same types being found in China, Japan, and the Riu Kiu Islands, and most of them in Formosa. Northern Luzon and Formosa, in numerous cases, present the most southern and eastern extension of the Himalayan flora, many of the Himalayan types found here not extending into the Malay Archipelago. Practically all of the Himalayan types found in northern Luzon also occur in Formosa, as noted above.
>
> About five hundred species of plants in the higher groups are known in the Philippines only from the Benguet-Bontoc region, indicating a distinctly specialized flora. Approximately three hundred fifty of these, or 70 per cent, are endemic so far as the Philippines are concerned, while the remaining 30 per cent are found outside of the Archipelago, chiefly in India, China, Japan, and Formosa. A very few species and genera extend south of the Mountain Province on the higher mountains, some even occurring at higher altitudes in Mindanao, and a few extend as far

south as Celebes and Timor. This indicates a very long period since the original plants came into the Philippine Islands, allowing for the development of very numerous endemic species and no less than six endemic genera.

If we examine the flora of the Benguet-Bontoc region by larger groups, for example, families, we find two striking facts. The families essentially characteristic of the temperate regions are relatively strongly developed, while the families highly developed in tropical regions are very poorly represented. Thus, such essentially temperate families as the following seventeen are well represented in the Benguet-Bontoc region:

Pinaceæ (one species of *Pinus*, but dominant).
Gramineæ.
Cyperaceæ.
Juncaceæ.
Liliaceæ.
Caryophyllaceæ.
Ranunculaceæ.
Berberidaceæ.
Saxifragaceæ.
Rosaceæ.
Violaceæ.
Ericaceæ.
Primulaceæ.
Gentianaceæ.
Labiatæ.
Scrophulariaceæ.
Compositæ.

In contrast to this, the families that are in general strongly developed at low and medium altitudes in the Philippines and in other tropical countries are either entirely unrepresented in the Benguet-Bontoc region or are represented only by few species, practically none of the few species that do occur there being confined to the Benguet-Bontoc region. Perhaps the most striking case is the Dipterocarpaceæ, the family being represented in the Philippines by nine genera and about fifty species, and dominant in the primary forests of the entire Archipelago at low and medium altitudes. No representative of the family is known from the region under discussion. The twenty-four tropical families either unrepresented or very poorly represented in the Benguet-Bontoc region are as follows:

Pandanaceæ.
Palmæ.
Nyctaginaceæ.
Anonaceæ.
Myristicaceæ.
Capparidaceæ.
Connaraceæ.
Meliaceæ.
Sterculiaceæ.
Malvaceæ.
Dipterocarpaceæ.
Ochnaceæ.
Guttiferæ.
Dilleniaceæ.
Flacourtiaceæ.
Lecythidaceæ.
Combretaceæ.
Sapotaceæ.
Ebenaceæ.
Apocynaceæ.
Convolvulaceæ.
Verbenaceæ.
Bignoniaceæ.
Acanthaceæ.

If we examine the geographic distribution of smaller groups, that is, the genera, we find that the same fact holds true. It is unnecessary to enumerate here the very numerous essentially tropical genera which occur elsewhere in the Philippines but which do not occur at all or, if present, then very poorly represented in the Benguet-Bontoc region.

The following seventy genera are essentially confined to the Benguet-Bontoc region so far as their occurrence in the Philippines is concerned:

Taxus (also on Mount Banahao)[20].
Pinus (also in Zambales and one species in Mindoro).
Agrostis.
Aniselytron.
Arundinaria.
Brachypodium.
Bromus.
Calamagrostis.
Chionachne.
Deschampsia.
Microlaena.
Monostachya.
Poa.
Luzula.
Aletris.
Asparagus.
Disporum.
Lilium.
Liriope.
Saururus.
Thesium.
Arenaria.
Sagina.
Stellaria.
Anemone.
Ranunculus.
Thalictrum.
Berberis.
Mahonia.
Sedum.
Astilbe.
Deutzia.
Fragaria.
Rosa.
Dumasia.
Lespedeza.
Shuteria.
Boenninghausenia.
Skimmia.
Sarcococca.
Pistacia.
Vitis.
Daphne.
Carionia.
Epilobium.
Acanthopanax.
Loheria.
Swertia.
Petalonema.
Bothriospermum.
Calamintha.
Plectranthus.
Teucrium.
Alectra.
Bythophytum.
Ellisiophyllum.
Hemiphragma.
Veronica.
Galium.
Peracarpa.
Lonicera.
Ainsliaea (also on Mount Banahao).
Anaphalis.
Aster.
Senecio.
Ethulia.
Carpesium.
Cirsium (also on Mount Banahao).
Merrittia.
Solidago.

It will be noted that practically all of these genera are those that are characteristic of the North Temperate Zone and poorly represented in tropical regions. Six genera, *Aniselytron*, *Monostachya*, *Carionia*, *Loheria*,

[20] Mount Banahao is an extinct volcano of Recent and Pleistocene ages, having an altitude of 2,188 meters, situated on the border of Laguna and Tayabas Provinces, about 350 kilometers south of Baguio. Three northern types occur at or near the summit of this mountain, but not elsewhere south of Benguet. They are *Taxus wallichiana* Zucc., *Cirsium philippinense* Merr., and *Ainsliaea reflexa* Merr., the first bird-distributed, the last two wind-distributed species.

Petalonema, and *Merrittia*, are monotypic, and are confined not only to the Philippines, but also to the Mountain Province.

In addition to these genera, other essentially temperate or subtemperate groups are much more strongly developed in the Benguet-Lepanto region than in other parts of the Philippines, being represented there by from one to several species, elsewhere in the Philippines usually by one or few forms and chiefly at higher altitudes farther south. They are—

Potamogeton.
Carex.
Juncus.
Rubus.
Smithia.
Impatiens.
Hypericum.
Viola.
Vaccinium.
Rhododendron.
Lysimachia.
Gentiana.
Cynoglossum.
Ajuga.
Salvia.
Sophubia.
Mosla.
Lobelia.
Bidens.
Gnaphalium.
Artemisia.
Eupatorium.

Australian types are poorly represented by two species of *Halorrhagis*, one endemic, the other extending from India to Japan southward to New Zealand, and *Uncinia rupestris* Raoul, in Luzon, Australia, and Hawaii. *Gaultheria borneensis* Stapf, known from Borneo (Mount Kinabalu), Formosa, and Benguet, is most closely allied to a New Zealand species. Our two endemic species of *Ranunculus*, confined to the Benguet-Bontoc region, find their closest allies in Australia and New Zealand, not on the Asiatic Continent.

Baguio Plateau, in a restrictive sense, is characterized by the dominance of *Pinus insularis*. In general, the flora of Baguio and vicinity, including Mount Santo Tomas, is very similar to that of other parts of the Mountain Province, lacking, however, certain genera that are found on the higher mountain peaks north of Baguio; namely, *Aniselytron*, *Anthoxanthum*, *Deschampsia*, *Monostachya*, *Poa*, *Luzula*, *Saururus*, *Ranunculus*, *Sarcococca*, *Loheria*, *Bythophytum*, *Peracarpa*, and *Solidago*. These genera, however, occur at Pauai (Haight's Place), on Mount Pulog, and on other high mountains in northern Benguet, in Lepanto, Bontoc, etc. Generally speaking, the Baguio flora is characterized by the occurrence of the genera enumerated for the Benguet-Bontoc region as a whole, eliminating the thirteen genera just enumerated. In most cases the last thirteen genera are represented in the Philippines by one species only; *Luzula* and *Ranunculus* have two species each. Tropical types, that is, families, genera, and species essentially characteristic of the Malayan Archipelago and the low altitudes of the Philippines, are no more prominently represented on the Baguio Plateau than they are in any other part of the Mountain Province.

Among the genera essentially confined to the Benguet-Bontoc region, so far as their occurrence in the Philippines is concerned, there are about seventeen that have adaptations for their dissemination through the medium of wind, and sixteen species which are apparently distributed by their fleshy fruits being eaten by birds. In the remaining thirty-seven cases no data are available as to adaptations for dissemination, although

it seems highly probable that many of the species may be distributed through their seeds being present in mud adhering to the feet or feathers of migratory birds, as in numerous cases very minute seeds are produced in great abundance, corresponding in general to the large series of rice-paddy weeds so predominant in the open low-country vegetation of the Philippines, and whose distribution can scarcely be explained on the basis of any other hypothesis than that just mentioned.

It is to be noted that the northern types are for the most part confined to the Benguet-Bontoc region in the Philippines. Many are essentially Himalayan, but others are confined to China and Luzon, Formosa and Luzon, and a few to Japan and Luzon. Practically all of the Himalayan types found in Luzon also occur in Formosa, indicating that they attained their present distribution at probably the same geologic time. It would seem that this might have been in the Oligocene or Lower Miocene age when Formosa and Luzon were connected with the Asiatic continent. These types may have at one time extended farther south, but if so, they have been exterminated by changes in climatic conditions. Very many of the Formosan-Luzon-Himalayan types are unknown from Sumatra, Java, and Borneo, and could scarcely have reached Luzon and Formosa through those islands. Summarizing, it would seem that from the time these Himalayan types reached the Philippines there has been continued high elevation in some part of the Benguet-Bontoc region, which has allowed them to persist. Most or all of them cannot grow under present climatic conditions at altitudes below 1,200 meters, while very many of them cannot grow below altitudes of 2,000 meters.

As far as Malaysia as a whole is concerned there were apparently two independent series of migration of Asiatic types, one through the Malay Peninsula to Sumatra, Java, Borneo, and the Philippines, and an earlier one through Formosa and Luzon to the Philippines, a few of which extended southward to Celebes.

Mr. Merrill's illuminating description clearly indicates that, at least since the beginning of the Miocene, mountains attaining elevations of 900 to 1,500 meters existed in Luzon. After the uplift of Baguio Plateau in middle or late Pleistocene time, the temperate flora from the greater heights of northern or southern Luzon invaded the newly formed Baguio Plateau, approved of its climate, and has continued to flourish there.

ACCELERATED TROPICAL PENEPLANATION

As was outlined in the introduction, the development of Baguio Plateau was rapid and the northern extension of this surface was great, according to Doctor Smith who correlates Mount Data Plateau with it. Now, the reader must remember that this surface cuts transversely the Baguio formation of probably late Pliocene or early Pleistocene age. This early old-age surface, or peneplain, was developed in the Pliocene, uplifted in the Pleistocene, and has over much of its former extent been chopped up into knife-edged mountain ridges 1,200 to 2,100

meters (4,000 to 7,000 feet) above sea level with deep 300- to 900-meter valleys between. Why, then, this great acceleration of geologic processes? Let us examine in detail the climate of this region.

CLIMATE OF BAGUIO PLATEAU

Baguio takes its name from the Spanish word for typhoon, "baguio," and deservedly so, considering the climate of this region. The excellent works of the Philippine Weather Bureau describe Baguio climate very well. Father José Coronas, chief of the meteorologic division of the Weather Bureau,[11] furnishes contrasting data between Baguio and other stations, as follows:

	°C.
Baguio, mean annual minimum	8.8
Manila, mean annual minimum	15.3
Baguio, annual normal	17.9
Manila, annual normal	26.4
Baguio, mean annual maximum	26.6
Manila, mean annual maximum	39.3

On page 337, Coronas summarizes these conditions as follows:

1. The mean annual temperature of Baguio, 17.9° C., differs from that of Manila by —8.5° C. The differences of the monthly means vary from —7.5° C. in December to —9.3° C. in May.

2. The mean annual range of temperature, that is, the difference between the mean temperature of the warmest month and the mean of the coldest month, is 2.4° C., somewhat smaller than that of other nearby stations on the sea level.

3. The lowest air temperature in 16 years has been 3° C. The mean of the annual minimum temperatures, however, is 7.4° C. for the first period of observations, and 9.9° C. for the second period. In our Temperature Map the mean of the two periods is given. The absolute minimum 3° C. was recorded in January, 1907, which was an extraordinarily cold year for Baguio.

4. Speaking in general, we may say of the temperature of Baguio that it is about 8 or 9 degrees lower than that of the other stations of Luzon on the sea level, but otherwise it follows the laws of a characteristically tropical climate as to the diurnal, monthly, and annual range, as to the warmest and coldest months of the year and the warmest and coldest hours of the day, etc., etc.

Before finishing this chapter, the attention of our readers should be called to a fact which may help to have a better knowledge of the climate of Baguio and may be of special value to agriculture. We had heard at times that real frost was observed and even a thin crust of ice formed in little pools at the foot of Mount Mirador, even when the air temperature both on the top of Mirador and in another station on a plateau near the City Hall was several degrees above the freezing point.

[11] The climate and weather of the Philippines, 1903–1918, The Philippine Census 1 (1920). In the temperature map, facing page 352.

During the winter of 1918 to 1919, the observer at Mirador, Mr. Pastor P. Daroy, made a series of observations which leave no doubt on this matter.

Temperature alone would not give Baguio its fine climate, but the fortunate distribution of rainfall or, rather, its concentration in July, August, and September leave the rest of the year balmy and pleasant, in marked contrast to Mount Banahao where, with even lower temperature, the rainfall is distributed throughout the year. Coronas in a note upon rainfall describes general conditions as follows:[12]

> There cannot be any doubt that the most interesting feature of the climate of the Philippines is the monthly distribution of rainfall. If this element would be about the same throughout the Archipelago, there would hardly be any difference of climate in the Philippines. But as it is, the different position of the islands which makes them or part of them more or less exposed to the general winds prevailing in the Philippines, both in winter and in summer, is the principal cause of our different kinds of climate in spite of the relatively small extension of the Archipelago from east to west, especially in Luzon. In winter the rains of the Philippines are mainly due to the northeasterly air currents, which, coming directly from the Pacific, cause abundant rains to fall over the eastern part of the Archipelago. Hence they are sometimes called "NE monsoon rains." In summer and autumn our rains are mainly due to the influence of typhoons which either cross the Islands, generally from eastsoutheast to westnorthwest, or pass some distance to the north. These rains, though quite general throughout the Archipelago, are more abundant in Luzon and the Visayas, and exceptionally heavy at times in the western part of these Islands which is more exposed to the westerly and southwesterly winds. As the great majority of typhoons that occur from June to October pass to the NE or N of the Philippines or cross the northern part of Luzon, the winds from west and southwest are the most prevailing during that season. This summer and autumn rainfall may be rightly called "cyclonic rainfall" as distinguished from the "NE monsoon rainfall." These cyclonic rains are far from being continuous, their frequency depending entirely on the frequency of typhoons.

Coronas recognizes four types of rainfall distribution. The first type has two pronounced seasons, dry in winter and autumn. The second type has no dry season with pronounced maximum in winter. The third type is characterized by no very pronounced maximum rain period and by a short dry season, from one to three months in length, while the fourth type has no maximum rain period and no dry season. Baguio has the marked characters of the first type, as fig. 4 shows clearly.

The great variation in the amount of the annual rainfall in Baguio is shown graphically by fig. 5, from the Census.[13] Even

[12] Op. cit. 342. [13] Op. cit. 355.

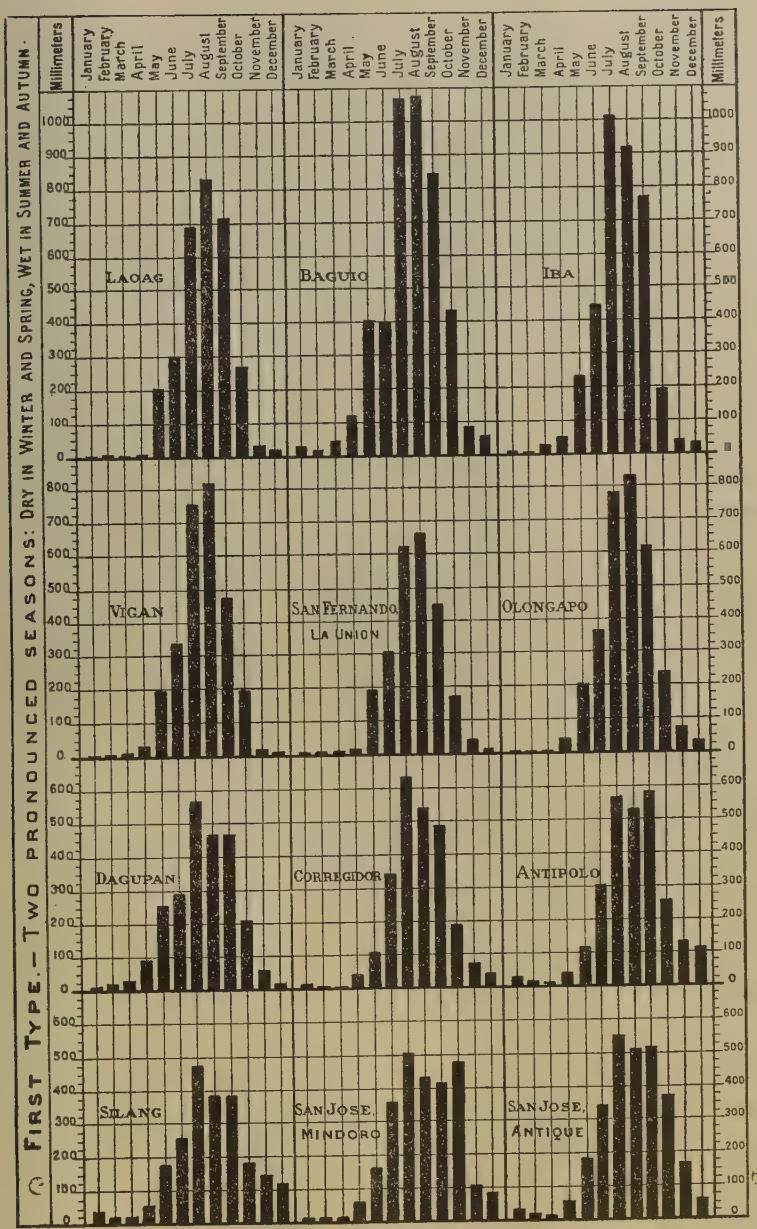

FIG. 4. First type of monthly distribution of rainfall in the Philippines; two pronounced seasons.

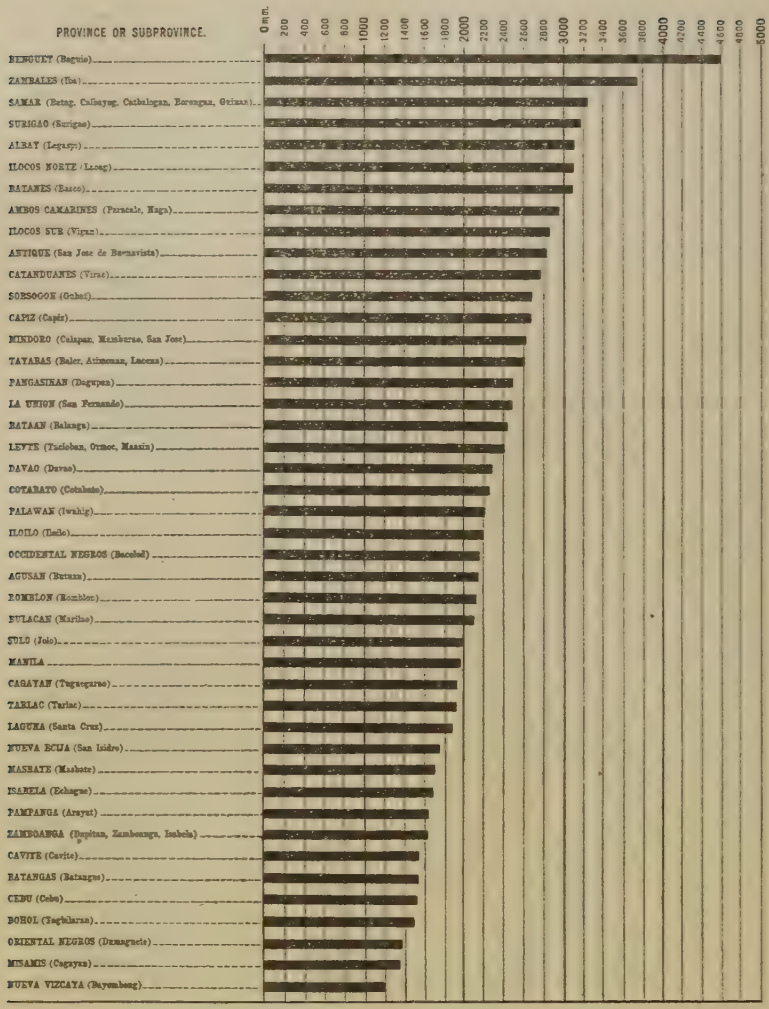

FIG. 5. Average annual rainfall of provinces and subprovinces.

with the great record of 9,038.3 millimeters (355.84 inches) made in Baguio in 1911, this station is greatly exceeded by that of Cherrapunji, Khasi Hills, India, whose average annual rainfall is 10,820 millimeters (426 inches), and by Mount Waialeale Station, Kauai Island, Hawaiian Islands, which reports 561 inches rainfall from May 21, 1915, to May 30, 1916.

However, as pointed out in the introduction, the torrential character of the rainfall, taken together with a great annual precipitation, is the chief concern of the geologist in considering the problem of the rate of development of land forms. The world's record for this characteristic is claimed by Baguio. Coronas described this event as follows:[14]

> As to Baguio, the absolute maximum rainfall observed in a single day is as great as 879.8 mm., an amount which is above the annual average rainfall of many cities of Europe and of the United States. This heavy rain occurred during a typhoon which crossed the northern part of Luzon on July 14 to 15, 1911. No less than 2,238.7 mm. of water were collected by the rain gauges of Baguio in four days, as follows: July 14, 879.8 mm.; July 15, 733.6 mm.; July 16, 424.9 mm.; and July 17, 200.4 mm. These daily amounts of rain are counted as it is customary in the Philippines from 6 a. m. of one day to 6 a. m. of the next day. But the most remarkable thing is that taking only the period of hours in which the rains fell with most heaviness, we have the incredible amount of 1,168.11 mm. recorded, as shown in a Friez Quadruple Register, in only 24 hours, from noon of the 14th to noon of the 15th.
>
> Although Baguio is not one of the wettest places of the world, yet the record of 1,168.1 mm. in 24 hours is considered, as far as known, a world's rainfall record for a period of 24 consecutive hours.

As was indicated above, the principal controls of climate are the typhoons taken together with the mountainous character of the Philippine Islands. Baguio is centrally situated as respects typhoon tracts, as most Philippine typhoons either pass over Baguio or are sufficiently near, either to the north or to the south, that Baguio is under their influence. This is well shown in fig. 6 which is copied from Coronas's work.[15] That elevation is a factor is shown by comparing graphs for Laoag on the seacoast north of Baguio and for Iba on the south coast, see fig. 5, but even these stations have an enormous rainfall as compared with stations in the United States. If the Baguio region were 900 meters (3,000 feet) lower than to-day its rainfall would even then be quite sufficient to accelerate the processes of erosion. In Pleistocene time these same climatic controls probably prevailed, and the process of the reduction of a high mountainous region to a gently rolling upland which merged into a coastal plain was exceedingly rapid. Likewise, since the uplift of Baguio Plateau, erosion has over large tracts of country completely removed all traces of this early old-age surface.

[14] Op cit. 379. [15] Op. cit. 456.

FIG. 6. Tracks of remarkable typhoons, 1914 to 1918.

SUMMARY

Baguio Plateau is a remnant of an early old-age surface, formed during a portion of Pleistocene time, uplifted to the present elevation of 1,200 to 1,500 meters, and largely eroded during Recent time (Plate 12, fig. 2). Various northern extensions of this peneplain have been recognized at Mount Data and intervening points by Dr. Warren D. Smith. Botanical evidence indicates that in the northern half of Luzon distant mountains with elevations of from 1,050 to 1,500 meters or more were present, and upon these elevations the ancestral stock of the present upland temperate flora was preserved. The vast acceleration of geologic processes in the Tropics is not due to mere quantity of rainfall, but to rainfall delivered as torrential downpours. The irresistible energy of the streams carrying these great volumes of water quickly leveled the mountains of early Pleistocene time over much of the area of the northern half of Luzon and reduced them to gently rolling hills and intervening wide shallow valleys. In late Pleistocene time this surface was uplifted in at least two and probably three stages, as the Amsalsal Plateau and the two terraces encircling Trinidad Valley indicate. Accompanying this uplift, faulting upon a great scale upthrust such masses as Mount Santo Tomas and the high mountain in northern Luzon, Mount Data.

Baguio Plateau cuts across rocks of various ages, diorites of the basement complex, Vigo-Miocene sandstones, Malumbang limestones, and the tuffs and agglomerates of the Baguio formation (Plate 12, fig. 3). This plateau is now in a geologic sense rapidly disappearing, through a process of rapid erosion aided by solution of underlying limestone and slides upon the plateau edge due largely to this sapping action, and owing to these agencies our descendants of a few thousand years hence will not enjoy this charming fairy-land.

ILLUSTRATIONS

PLATE 1

Relief model of Baguio, showing striking contrast between Baguio Plateau and the deeply incised valleys of Bued River, Gold Creek, and Antamok River. (From the model made in the Bureau of Science from the map by A. J. Eveland.)

PLATE 2

Topographic map of Trinidad Valley and vicinity.

PLATE 3

Panorama of Baguio Plateau taken from Mount Mirador looking to the north and east. Naguilian Trail on the left; the rugged limestone hill on the left at the skyline is one of the portals of Trinidad Water Gap. The rounded hills in the background are those of Pacdal. Dominican Monastery, on the right. A small residual of Baguio formation resting unconformably upon Pliocene limestone is seen just beyond the fork of Mount Mirador and Dominican Roads. (Photograph by Father Algué.)

PLATE 4

FIG. 1. Mount Data, showing fault scarp on the east side. (Photograph by W. D. Smith.)

2. Haight's place, Pauai, showing remnant of old erosion surface. (Photograph by W. D. Smith.)

3. "Hanging valley" of old erosion surface near kilometer 81 on trail from Baguio to Mount Data. (Photograph by W. D. Smith.)

PLATE 5

FIG. 1. Westerly dipping Malumbang limestone about 4 kilometers west of Baguio City Hall on the Naguilian Road.

2. Unconformable contact between arkosic Vigo sandstone and the overlying northerly dipping Malumbang-Pliocene limestone. The fragments embedded in the limestone consist of the stems of coral algæ.

3. Detail of coralline limestone showing abundance of stems of coral. East side of Trinidad River, in center of Trinidad Water Gap, south entrance.

PLATE 6

FIG. 1. Klondike's place near camp 1. Pliocene corals were collected from conglomerate strata at the end of the bridge. A small *Pecten* sp. was found in the sandy matrix of the conglomerate 10 meters from the house toward the left of the picture.

2. Baguio from Pacdal, showing the sharp contrast between the Santo Tomas fault block and Baguio Plateau.

FIG. 3. Mount Santo Tomas in the background; characteristic slide topography on the southwestern edge of Baguio Plateau. From a point near Government Center.

PLATE 7

The Zigzag on Benguet Road. Bued River Cañon on the right.

PLATE 8

FIG. 1. Bued River Valley. (Photograph by A. J. Eveland.)
2. Baguio Hospital, on the outer edge of Baguio Plateau. At the extreme left, slices of the Baguio formation are being slipped off from season to season. Mount Santo Tomas is the highest peak in the background.

PLATE 9

FIG. 1. Loacan Valley, showing present small stream occupying the exceedingly wide shallow valley. Mount Santo Tomas in the background.
2. Baguio City in 1905. (Photograph by A. J. Eveland.)

PLATE 10

FIG. 1. Flora from Baguio tuffs near Government center. *Clethra lancifolia* (Turcz.).
2. Loacan Valley from Mount Santo Tomas Trail.
3. North-dipping coralline limestone beds, east side of Trinidad Valley, and compact andesitic tuff-breccia of the Baguio formation. The low gap marks the location of a prominent fault between the above-mentioned beds.

PLATE 11

FIG. 1. Close view of Trinidad Water Gap, looking south from the provincial capitol. Marshy area in the foreground, Pacdal Hills in the background.
2. North-dipping limestone on east side of Trinidad Valley. Fault between this limestone and hard resistant andesitic breccia of the Baguio formation is marked by the low gap in the center. This low gap is not the exit of Trinidad River, but this gap was formed long after Trinidad River was intrenched in its north water gap which lies between the rounded hills on the left and the hill slope on the extreme left. One bowlder eroded from Malumbang coralline limestone was found near the top of the rounded hill on the left, and other fragments were found on the hill slope about the extreme left edge of this picture. Definite stream gravels occurred slightly to the left beyond the picture.
3. Looking south across Trinidad Valley, Trinidad farm school buildings in the left center. A 4,850-foot terrace on the left; hills around Baguio seen beyond Trinidad Water Gap. Hills on the right consist of Malumbang limestone.

PLATE 12

FIG. 1. View of the western and southern side of Trinidad Valley, illustrating the difference in character of hill forms in the coralline limestone on the left and the soft Baguio tuffs on the right. The marshy area marking a portion of the old ox-bow course of Trinidad River is located just beyond the provincial capitol.

2. Amsalsal Plateau from the east side of North Trinidad Valley Water Gap. A correlative of this plateau is dimly outlined on the right. This plateau probably represents a substage in the development of Baguio Plateau.

3. Mount Mirador, illustrating the rugged character of the Malumbang coralline limestone.

TEXT FIGURES

FIG. 1. Sketch map showing Baguio and a portion of central Luzon.

2. Sketch map of Mount Data, Mountain Province, Luzon. (By Warren D. Smith, 1922.)

3. Geologic sketch map of Baguio and vicinity.

4. First type of monthly distribution of rainfall in the Philippines; two pronounced seasons. [After Coronas in Census of the Philippine Islands 1 (1920) 349.]

5. Average annual rainfall of provinces and subprovinces. [After Coronas in Census of the Philippine Islands 1 (1920) 355.]

6. Tracks of remarkable typhoons, 1914 to 1918. [After Coronas in Census of the Philippine Islands 1 (1920) 456.]

PLATE 1. RELIEF MODEL OF BAGUIO. IN THE HORIZONTAL SCALE 1 CENTIMETER EQUALS ABOUT 565 METERS.

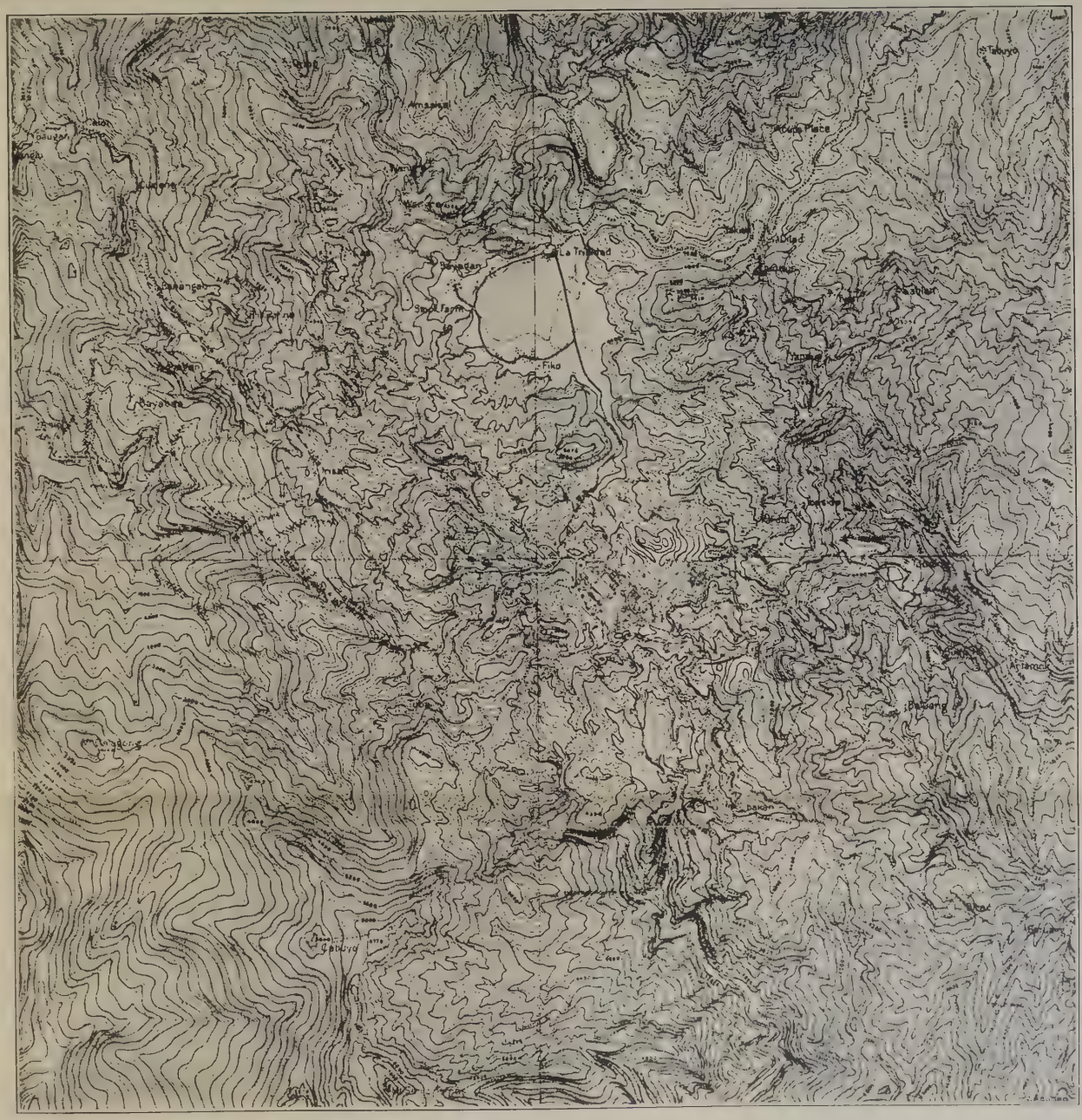

PLATE 2. TOPOGRAPHIC MAP OF TRINIDAD VALLEY.

PLATE 3. PANORAMA OF BAGUIO PLATEAU TAKEN FROM MOUNT MIRADOR.

Fig 1. Mount Data, showing fault scarp on the east side.

Fig. 2. Haight's place, Pauai, showing remnant of old erosion surface.

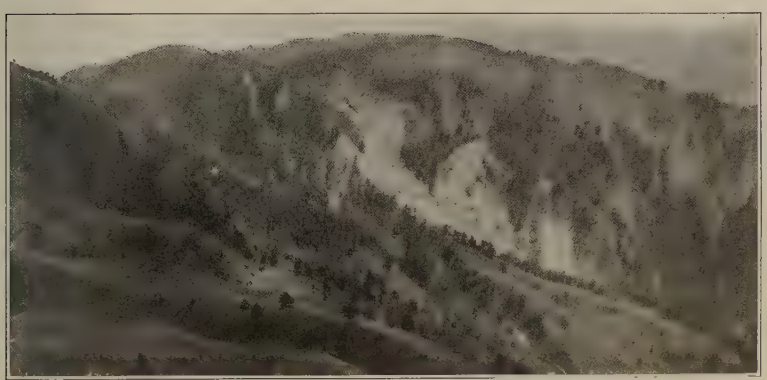

Fig. 3. Showing "hanging valley" of old erosion surface near kilometer 81 on trail from Baguio to Mount Data.

PLATE 4.

Fig. 1. Westerly dipping Malumbang limestone about 4 kilometers west of Baguio City Hall.

Fig. 2. Uncomformable contact between arkosic Vigo sandstone and the overlying northerly dipping Malumbang.

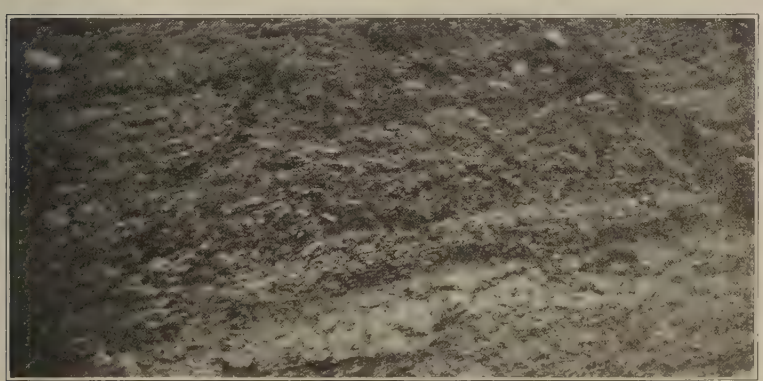

Fig. 3. Detail of coralline limestone, showing abundance of stems of coral.

PLATE 5.

Fig. 1. Klondike's place near camp 1.

Fig. 2. Baguio from Pacdal.

Fig. 3. Characteristic slide topography on the southwestern edge of Baguio Plateau.

PLATE 6.

PLATE 7. THE ZIGZAG ON BENGUET ROAD. BUED RIVER CAÑON ON THE RIGHT.

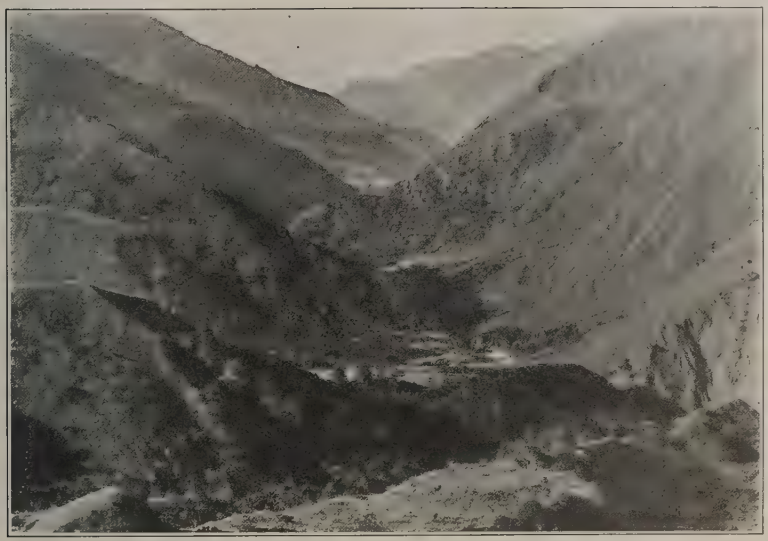

Fig. 1. Bued River Valley.

Fig. 2. Baguio Hospital, on the outer edge of Baguio Plateau.

PLATE 8.

Fig. 1. Loacan Valley, showing present small stream occupying the exceedingly wide shallow valley.

Fig. 2. Baguio City in 1905.

PLATE 9.

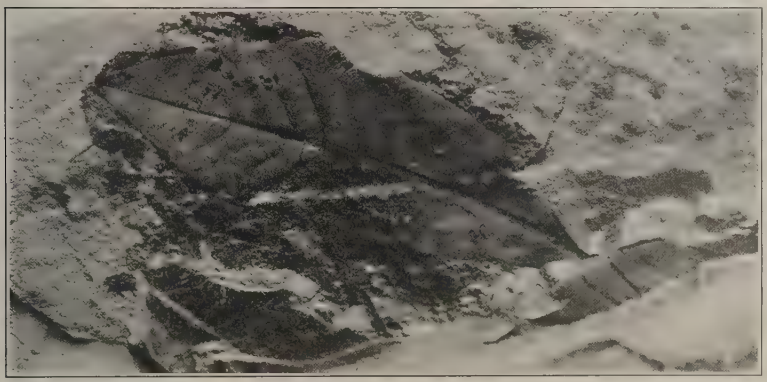

Fig. 1. Flora from Baguio tuffs near Government center. Clethra lancifolia (Turcz.).

Fig. 2. Loacan Valley from Mount Santo Tomas Trail.

Fig. 3. North-dipping coralline limestone beds, east side of Trinidad Valley.

PLATE 10.

Fig. 1. Close view of Trinidad Water Gap, looking south from provincial capitol.

Fig. 2. North-dipping limestone on east side of Trinidad Valley.

Fig. 3. Looking south across Trinidad Valley.

PLATE 11.

Fig. 1. View of the western and southern side of Trinidad Valley.

Fig. 2. Amsalsal Plateau from the east side of North Trinidad Valley Water Gap.

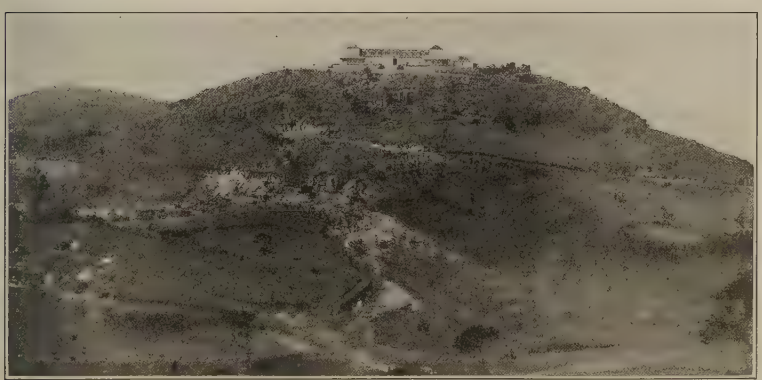

Fig. 3. Mount Mirador, illustrating the rugged character of the Malumbang coralline limestone.

PLATE 12.

THE TREATMENT OF HOOKWORM INFESTATION WITH CARBON TETRACHLORIDE

A CLINICAL AND LABORATORY STUDY

By CHARLES N. LEACH
Of the International Health Board
FRANK G. HAUGHWOUT
Of the Bureau of Science, Manila
and
J. EARLE ASH
Major, Medical Corps, United States Army

ONE PLATE

INTRODUCTION

The work that forms the basis of this report was first undertaken early in May, 1922, at a time when reports of a more or less contradictory nature concerning the safety of carbon tetrachloride in the treatment of hookworm infestations in man were being published from various parts of the world. Most of these reports constituted the products of field work, by men who had neither the opportunity nor the facilities for detailed study, so we reached the conclusion that the time had arrived for making a start toward the promulgation of a more precise knowledge concerning the action of the drug. We early gained the impression that many of the accidents that had occurred might be traced to the use of an impure drug, so we determined to study the action of the pure drug in as much detail as possible.

The opportunity for doing this presented itself in Bilibid Prison, in Manila, which has been the scene of many notable studies in experimental medicine. The project was rendered the more feasible by reason of the amiability with which the average Filipino submits himself to reasonable experimentation. We desire to record our appreciation of the willingness with which our volunteer subjects entered into the work.

Most of all, however, must we record our gratitude to Dr. Henry Pick, chief of the prison sanitation division of the Phil-

ippine Health Service and resident physician and surgeon at the prison hospital, who really made it possible to carry out the study successfully. Doctor Pick placed his hospital, laboratory, and quarantine shed completely at our disposal, furnished us with efficient attendants, and assisted us in many other ways. We also must record our appreciation of the aid given us from time to time by Mr. Philip Jones, chief inspector of the prison, who facilitated our movements in the prison as a whole. In addition to those specifically mentioned in various parts of the paper, we desire to thank Maj. Harry A. Oliver and Capt. R. C. Kirkwood of the United States Army Medical Corps, and Dr. Hilario G. Lara of the Philippine Health Service, who gave us incidental aid at times when one or another of us was temporarily called to other duties.

At the time the work was started we planned to make a study of the elimination of the drug and had invited Mr. Albert H. Wells, chief of the division of organic chemistry of the Bureau of Science, to join us. Pressure of other work, however, prevented us from carrying out this plan, which has been deferred to a later date.

We have reported on this work, which represents observations on one hundred men, in considerable length, because we do not by any means consider that we have said the last word on any of the themes we have discussed. We think it wise, therefore, to give our findings in some detail in order that they may be available to other workers who may desire to check or criticise our report.

It is now apparent that carbon tetrachloride as an anthelmintic against hookworm possesses virtues that can be claimed by no other drug of which we have knowledge; while we believe it is safer than other drugs employed for the same purpose, we feel that much remains to be added to our knowledge concerning its pharmacology, and the extent and duration of pathological effects it may sometimes bring about. Nevertheless, we feel constrained to say that the trepidation we felt in the beginning concerning the administration of the drug has been stilled as a result of our observations. We still recall the half-hesitation, in the face of adverse reports from other places, with which we administered our first doses of 10 cubic centimeters, to three condemned men. Since then we have felt no anxiety in administering 12.5 and even 15 cubic centimeters, in selected cases.

So far as concerns the toxicity of the drug we find ourselves able, at the conclusion of the work, to state that not only did

we have no deaths, but also that in no case treated under our supervision have symptoms of intoxication developed that called for treatment or that gave us the slightest anxiety. We have felt such confidence in our results that we have not hesitated to treat many thousands of cases elsewhere in the Philippines on precisely the same dose standards we employed with these men. So far, there have been no accidents.

MATERIAL AND METHODS

In undertaking this study we laid down two basic principles with respect to the employment of the drug. In the first place, we determined to administer no carbon tetrachloride the purity of which was subject to the slightest question. To that end every lot of the drug that was used was purchased as a pure product from a drug house of established reputation. Before use, it was tested for impurities under the direction of Mr. Wells. We take pleasure at this time, in extending our thanks to Mr. Wells for his interest and coöperation.

We think it opportune at this time to repeat the warning contained in a memorandum kindly prepared for us by Mr. Wells, in response to our request for information concerning the chemical problems involved in the issuance of carbon tetrachloride designed to be administered to human beings. We deem this necessary because we have records of not less than three fatalities in the Philippines that appear to be associated with the administration of an impure drug. Unfortunately we could secure only the barest details of these cases. We were informed that the drug was purchased from a Manila pharmacy and was sent to the user in a soda water bottle labeled "Carbon Tetrachloride, C. P.," and was administered in good faith. Death in these cases seems to have followed the development of symptoms highly suggestive of drug intoxication. Mr. Wells has written us as follows, under date of March 31, 1923:

> Carbon tetrachloride received by the Bureau of Science and often marked "c. p." contains carbon disulphide, aldehydes, and traces of chlorides and sulphur. A recent shipment of 1,000 liters contained an excessive amount of carbon disulphide.
>
> The usual procedure for purification of this product depends upon the impurities present but in full is as follows:
>
> The carbon tetrachloride is refluxed with an oxidizing solution of sulphuric acid and potassium dichromate, distilled off, treated with 15 per cent sodium or potassium hydroxide solution with agitation, separated, washed with water, dried with calcium chloride, and carefully redistilled in glass.

The physical condition of every subject was carefully ascertained by physical and laboratory examination. This enabled us to guard against possible physical contraindications to the treatment, and also gave us a check on the action of the drug under various conditions of pathology in the subject.

The subjects were picked from long-term prisoners, just arrived at the prison. The examinations and treatment were carried out during their term of detention in the quarantine sheds. The men were constantly under the supervision of a trained attendant, so that they were under observation during the entire period of examination and treatment. In all instances where stools were lost or there was any suspicion that anything had occurred essentially to mar the continuity of the record, the case was thrown out and another substituted for it.

In order that the data might be considered uniformly, all the information was placed on individual protocols, the entire record of each case being contained on one sheet as follows:

CARBON TETRACHLORIDE SERIES; BILIBID PRISON, 1922

Prison No ---------- Exp. No ----------
Name ---------- Age ---------- years.
Residence ---------- Nationality ----------
Social state, M. S. W. ---------- Occupation ----------
Sentence expires ---------- ----------

LABORATORY DATA

FÆCES.	Helminths.	Protozoa.	Miscellaneous.

Remarks: ----------

BLOOD.	Before.	____ hours after.	2 weeks after.
Total R. B. C.			
Total W. B. C			
Hæmoglobin			
Color index			
Poly neutros			
Poly eosinos			
Small lymphos			
Large monos			
Mast cells			
Anisocytosis			
Poikilocytosis			
Normoblasts			

LABORATORY DATA—Continued

Urine.	----- before.		----- after.	
Quantity	Albumin	Quantity	Albumin	
Color	Crystals	Color	Crystals	
Odor	Casts	Odor	Casts	
Reaction	Cells	Reaction	Cells	
Sp. grav	Sugar	Sp. grav	Sugar	

PHYSICAL EXAMINATION AND TREATMENT

Date ..... 1922. Examiner .....

Weight { Before treatment ..... kgm.
After treatment ..... kgm.

Narcotics .....
Family history .....
.....
Previous personal history .....
.....
Special senses ..... Skin and mucous membrane .....
Glandular system ..... Vascular system .....
Blood pressure { Before treatment, D ..... S .....
During treatment, D ..... S .....
Heart ..... Lungs .....
G. U ..... Nervous system .....
Muscles and joints ..... Osseous system .....
Abdomen:
Spleen .....
Liver .....
Tenderness .....
Masses .....

Date ..... 1922. Dose ..... cc. How given .....
Reaction of patient to drug .....
.....
First bowel movement ..... hours after treatment.

Worm count.	1st day.		2d day.		3d day.		Total.
	♂	♀	♂	♀	♂	♀	
A. duodenale							
Necator							
Ascaris							
Trichuris							
Oxyuris							
Tænia							

Although this form is self-explanatory, a few words concerning the laboratory methods employed are not out of place. The fæces examinations were made with great care in order to

detect and treat as many types of parasitic infestation as possible, and to discover the light as well as the massive infections. The protozoan findings are subject to the usual error arising from a limited number of examinations and, as the majority of the subjects were microscopically examined only once before treatment, no numerical value can be placed upon them.

Cover-glass preparations were made from each stool, and a sample was concentrated by the Cropper and Row ether-centrifuge method. In the entire group of subjects, there were only two who yielded hookworms on screening, the ova of which were not found before treatment. These two subjects yielded one and seven worms, respectively, on screening.

On the other hand, several exceedingly light infestations were detected microscopically, as is shown on surveying the cases from which ten worms or less were recovered on screening. These cases are recorded in Table 1.

TABLE 1.—*Subjects harboring ten hookworms or less.*

Subjects.	Worms recovered.
2	1
7	2
1	3
2	4
1	5
1	6
4	7
1	8
6	9
1	10

Examinations of the blood and urine were made by the usual methods. Hæmoglobin estimations were made with the Tallquist scale. None of this work was intrusted to laboratory technicians. Blood pressures were recorded with the Tycos apparatus.

A separate cell house was set aside for the accommodation of the men under treatment, and as soon as the drug was administered the water-closets were sealed to avoid loss of stools. Each man was furnished with a separate "jerry" which was marked with his number and name, and an attendant was told off to see that each man used his own receptacle.

On the night before treatment the men were given soft diet. This was done principally to lighten the work of screening the stools. Breakfast and luncheon were withheld and the drug

was administered in twice its volume of cold water at about 1.30 o'clock in the afternoon, the men being immediately marched into the cell house and made to lie down until the bowels began to move. One or more of the authors remained to watch the men and to take and record the pulse and blood pressure of each man one hour after treatment. Such of the men as cared to do so were allowed to eat their evening meal at about 5 o'clock. Stools were collected for three days and carefully screened to recover the worms, after which the men were released from quarantine.

The stools were washed through a screen of sixty meshes to the inch. This probably was finer than necessary, but it was the only screen available in Manila. The worms were preserved in 70 per cent alcohol and later cleared in 10 per cent glycerine-alcohol.

Reëxaminations of the blood and the urine were made twenty-four hours after treatment, and in a considerable number of the cases the blood was examined a third time. Eventually, the stool of each man was examined microscopically to determine if he had been rid of his worms.

Several men in the series were later deported and some others were transferred to a penal colony, so it was not possible to carry out a series of test treatments.

HELMINTHAL FINDINGS BEFORE TREATMENT

While it was desired principally to study the effects of carbon tetrachloride on hookworm infestation, it was thought wise to include a few subjects in which that parasite was not present. Of the men selected for experiment eighty-nine were found, on microscopical study, to harbor hookworms. The remaining eleven were infested with *Ascaris, Trichuris,* or both. Infestations with *Ascaris* to the number of fifty-three, and with *Trichuris* to the number of eighty-four, were found in the group. These infestations were distributed as shown in Table 2.

TABLE 2—*Distribution of helminthal infestations.*

Parasite.	Subjects infested.
Trichuris only	6
Ascaris and *Trichuris*	4
Hookworm only	9
Hookworm and *Ascaris*	6
Hookworm and *Trichuris*	31
Hookworm, *Ascaris,* and *Trichuris*	43
Oxyuris	1

PROTOZOAN INFESTATIONS

It was not anticipated that the drug would have any permanent effect on the intestinal Protozoa, with the possible exception of *Giardia*. Only four infections with *Giardia* were detected in the entire series, and we secured no evidence that any of these were affected in the slightest degree. Having in mind the error that obtains with respect to intestinal protozoan findings under a limited number of examinations, we feel justified in stating that carbon tetrachloride is without effect on any of the Protozoa detected by us during this study. We record our data in Table 3, for the purpose of making our record complete, and shall not make further allusion to the action of the drug on the intestinal Protozoa.

TABLE 3.—*Intestinal Protozoa found before and after treatment.*

Species.	Positive cases.		
	On first examination only.	On second examination only.	On both examinations.
Entamœba histolytica	2	5	1
Entamœba coli	5	18	15
Endolimax nana	3	1	0
Iodamœba butschlii	0	0	1
Trichomonas	4	0	0
Chilomastix	1	0	0
Giardia	0	2	2
Enteromonas	1	0	0
Embadomonas	1	0	0
Entamœba (undetermined)	1	1	0

STANDARDIZATION OF THE TREATMENT

Treatment of the men in this series was not started until we had carried out some observations on a group of three murderers condemned to death.[1] At the time, it was contemplated

[1] The observations on these three men were made by two of us, Leach and Haughwout, and do not form part of the work embraced in this report. Major George R. Callender, M. C., U. S. A., president of the U. S. Army Medical Department Research Board for the Philippine Islands, kindly studied the histological preparations and rendered the report we have incorporated here. The necropsy was performed and a report on it furnished to us by Captain Charles H. Manlove, M. C., U. S. A., whose experience in the pathological anatomy of Filipinos has been very extended. We extend our gratitude to these two gentlemen for the valuable assistance and counsel they have given us.

that these men would shortly become available for further investigation on the autopsy table, but the sentences of two were commuted to life imprisonment twenty-four hours before the time set for their execution; therefore, we secured a necropsy of only one man. Each man received 10 cubic centimeters of the drug three days before the date of the execution. The dose was arbitrarily fixed, and was 2 cubic centimeters below the maximum given by Leach to a man in Ceylon.(7) None of the men showed any marked reaction to the drug aside from headache and anorexia.

None of these men was heavily infested. Prisoner 18090 (the man who was executed), harbored 11 hookworms, only 1 of which was an ancylostome. The other two men, Nos. 18093 and 18095, harbored 12 and 42 hookworms, respectively.

The physical examination of prisoner 18090, was made just twenty-four hours prior to his execution, immediately after the death warrant had been read to him. The examination disclosed no physical abnormalities except some anæmia of the mucous membranes. The pulse was regular in rate and rhythm, 82 beats to the minute. Neither the spleen nor the liver was palpable.

The man was hanged at 11 a. m., and the body was delivered to us at 11.30. The thorax and abdomen were opened at 11.35. Captain Manlove's protocol is as follows:

> External examination shows the body to be that of a well-developed, well-nourished adult Filipino male. The skin over the thorax is covered with tattoo marks. No pigmentation. There is marked crepitation of the vertebræ of the cervical region. On section of the body there is a normal amount of subcutaneous fat. The muscle is reddish and appears normal.
>
> *Abdomen.*—The serosa covering the small intestine is pinkish, moist, and apparently normal. The abdominal viscera are normally placed. The diaphragm is normally placed.
>
> *Thorax.*—The lungs completely fill the thoracic cavity. There are a few adhesions in the right upper thoracic cavity; otherwise the pleural sacs are normal. The lungs, themselves, are considerably distended with air and collapse on section. The lung tissue is apparently normal.
>
> *Heart.*—The pericardial sac is normal. The heart is about normal in size. The right side of the heart, however, is distended with blood. The muscle is congested but apparently normal.
>
> *Spleen.*—About normal in size, shape, and consistence. On section considerable blood oozes from the cut surface, but otherwise it apparently is normal. The adrenals are normal in appearance, though slightly congested.
>
> *Kidneys.*—The kidneys are normal in size, shape, and consistence, but are markedly congested. Otherwise they are normal.
>
> *Liver.*—It shows marked congestion, but otherwise is normal.

GASTROINTESTINAL TRACT

Duodenum.—There is a slight hæmorrhagic area near the pyloric portion. Particles of undigested food are present; also mucus. Otherwise it is quite normal, and no worms are found. Contents of duodenum screened.

The intestinal tract was removed after first tying the duodenum at the pyloric end of the stomach, then at the extremity of the duodenum, and then tying off the jejunum at its extremities. The ileum, likewise, was tied off at its extremities. The ascending colon at the hepatic flexure was tied off and the transverse colon and descending colon were also tied off. These segments were then dissected out separately. The segments of intestine were then opened lengthwise over a receptacle, and their contents thoroughly washed out into a sixty-mesh-to-the-inch screen, washed and searched for worms.

Jejunum.—No parasites were found. The mucosa throughout was apparently normal with the exception of several slightly congested areas near the duodenal portion. Very large amounts of mucus were found in the jejunum. There also was a considerable amount of partially digested food.

Ileum.—The ileum contained a considerable amount of partially digested food and a large amount of mucus. The mucosa appeared normal. No worms were found.

Color.—Mucus membrane is normal. Contents consist of small amount of formed fæcal material. No parasites found.

It may be remarked in connection with the above, that the viscera are characteristically congested in subjects who have been executed by hanging.

As soon as the abdomen was opened, the kidneys and liver were removed and thin blocks cut from each and immediately fixed. Most of them were fixed in Zenker's fluid, but some also were fixed in Bouin's picro-aceto-formol fluid. Sections were cut 5 μ thick and stained with hæmatoxylin and eosin. Some of these were then submitted to Major Callender, who gave them very careful study. His report to us is as follows:

Sections of liver and kidney of adult male Filipino, executed by hanging, three days after taking 10 cubic centimeters of carbon tetrachloride. Tissues fixed in Zenker thirty-five minutes after death. Stained with Delafield's hæmatoxylin and eosin.

Sections of liver and kidney.—Fixation excellent.

Liver.—Larger veins distended with blood as are a few of the capillaries in the hepatic vein zones. Liver cells are granular, not swollen, nuclear markings distinct and normal throughout all sections. Many of the portal areas show an infiltration with lymphocytes and plasma cells of varying degree; that is, from a few cells about the vessels to an infiltration filling the greater part of the portal connective tissue. There are a few polynuclears in these areas and scattered in the capillaries and lymph spaces throughout the tissue and there are also a few lymphocytes out in the tissue. There is some proliferation of the epithelium lining the bile ducts without other obvious change. The capsule contains quite a few lymphocytes but not collected in masses.

Impression.—A mild degree of chronic cholangitis of some duration was present in this liver and an acute passive congestion. The latter is shown only in the larger vessels and can be accounted for by the method of death.

Kidney.—Old process. There are a few hyaline masses representing replaced glomeruli and a few of the glomeruli show beginning changes of similar character. There is no change obvious except in and in the vicinity of the glomeruli.

Acute.—There is an engorgement of the veins and glomerular capillaries with blood, some groups being much more intensely affected than others. There has been some absorption of fluid in the epithelium of the glomeruli and of the proximal convoluted tubules, but no change in staining reaction of the nuclei.

Impression.—Slight chronic glomerulo-nephritis. Acute passive congestion due to manner of death.

Photomicrographs of some of the sections studied by Major Callender are shown on Plate 1.

In their paper on the pathologic effects of carbon tetrachloride on the human liver, Docherty and Burgess(2) proceed on the basis afforded by the report of Smillie and Pessoa(9) who state that small doses of carbon tetrachloride produced fatty degeneration of the liver and kidneys in dogs.

Docherty and Burgess's experiments were made on three condemned prisoners in Ceylon. Two of these men received 5 cubic centimeters of the drug in single doses while the third was given a total of 8 cubic centimeters in two doses, the first of 5 cubic centimeters, and the second of 3 cubic centimeters, about two weeks later.

The first man was executed and went to autopsy six days after treatment. Macroscopically the liver showed no evident change. Microscopically there was "no well-defined change." There was no evident macroscopic or microscopic change in the kidney.

The second man was executed two weeks after treatment. Macroscopically, the liver was "slightly friable." Histologic sections of the same organ showed "granular degeneration of liver cells. Leucocytic infiltration." There was no evident macroscopic change, and no definite microscopic change in the kidney.

The third man, who received a total of 8 cubic centimeters of the drug, was executed eighteen days after treatment. Macroscopically, his liver was found to be "very friable." Microscopically, Docherty and Burgess report "Fatty degeneration of liver cells. Diffuse leucocytic infiltration." The kidney in this subject showed no evident change, but microscopically there was "cloudy swelling of proximal tubes."

On the basis of this evidence Docherty and Burgess conclude:

> From the above it is quite evident that the anthelmintic, in the quantities mentioned, produced lesions in the liver in two cases, as Smillie anticipated; on this account it seems inadvisable to prescribe even a 5 c.cm. dose with purgation, let alone without it.

We feel compelled to disagree radically with the above conclusion. We are not convinced that the drug produced the lesions described by Docherty and Burgess. Leucocytic infiltration, so far as we are aware, is not produced by drug intoxication. Leucocytic infiltration of the liver is to be seen in a fairly large proportion of natives of the Tropics and is possibly the expression of a more or less inactive infectious process in the intestine. It is to be noted that Major Callender reports it among his observations on one preparation. The only significant thing we can see in Docherty and Burgess's report is the finding recorded as "fatty degeneration of liver cells," but even there evidence is lacking in support of the statement that it was caused by carbon tetrachloride. It appears from the record of this case, however, that this man's bowels did not move for the first twenty-four hours after he took his first dose of 5 cubic centimeters of the drug. The drug was administered at 8 a. m. Two hours later he complained of dizziness and nausea and immediately vomited the cathartic (salts) that had been given him at 4 p. m. The second installment of the treatment apparently gave him no discomfort. We add these facts simply to make the record complete, and not because we believe that the retention of the drug worked the man any real damage. Two men in our own series went for nearly twenty-four hours after treatment without a bowel movement, at the end of which time we gave them salts. They showed no untoward symptoms.

The chemical structure of carbon tetrachloride and chloroform, and what we know of the pharmacology of the two substances, give ground for the belief that their action upon the organism, when absorbed in harmful quantities, may be very similar. The action of chloroform upon the liver is too well known to require discussion here, but a review of the anatomy of this organ makes it clear that the location of lesions in the liver with reference to the anatomical structure has a distinct importance in considering the genesis of liver pathology. The report of Docherty and Burgess states that fatty degeneration was present, but omits a description of the character and location of the lesions, so it is impossible for us to satisfy ourselves that the fatty change was due to carbon tetrachloride and not

to some concomitant condition of another nature, and possibly from a different location. This is not a quibble; it is very germane. In view of the frequent pathology found in tropical livers, we consider this a very important point to determine. Interpretation of such findings should be made with strict attention to the fallacy of concomitant variations.

In our judgment, it will require more complete and convincing evidence than Docherty and Burgess have produced to establish that pure carbon tetrachloride in doses of 5 to 8 cubic centimeters will produce lesions in an adult liver save in very exceptional circumstances or where a disorder of the liver already exists. Another very important desideratum that we feel should be borne in mind in connection with the work of both Smillie and Pessoa, and Docherty and Burgess, is that neither publication contains definite information regarding the grade of purity of the drug used. We are of the opinion that discussions regarding the toxicology of carbon tetrachloride are futile unless they are accompanied by a definite statement regarding the chemical purity of the carbon tetrachloride that was employed in the experiments.

In connection with the above, it should be noted that our subject was necropsied three days after treatment, while Docherty and Burgess's men went to autopsy six days, fourteen days, and eighteen days, respectively, after the drug had been administered.

The foregoing clinical and pathological observations having made it clear to us that our man had sustained the administration of 10 cubic centimeters of carbon tetrachloride without organic damage, and the other men having in the meantime shown no ill effects, we decided to base our future work on the standard afforded by him. The man was a fair physical representative of the men with whom we were to deal. His weight before execution was 54 kilograms, so that simple calculation showed that he had been treated on the basis of 1 cubic centimeter of the drug to each 5.4 kilograms of body weight. We thereupon fixed as a maximum dose-basis for treatment 1 cubic centimeter of carbon tetrachloride to each 5.5 kilograms of body weight.

We consider it unnecessary at this time to review the work of all those who have experimented in the treatment of hookworm infestation with carbon tetrachloride. Few apparently have ventured to administer the drug in the doses we have employed, yet some have reported toxic effects of a grave nature

on the administration of doses as low as 3 cubic centimeters, and not a few have expressed serious doubts regarding the safety of the drug. We never have administered a dose as small as that to any adult, yet in no instance have symptoms developed in our series that have given us the slightest cause for anxiety. In another part of this paper we shall discuss accidents that have happened to persons who were not under our control.

We are of the belief that the use of carbon tetrachloride involves the exercise of the same medical knowledge and judgment as are required in the administration of any other powerful drug. We further believe that most instances in which untoward symptoms supervene may be traced to either impurity of the drug, alcoholism, or disease of the liver. We place these factors in what we believe to be their order of usual occurrence. While we do not criticize the product of any reputable drug manufacturing house, we have from the beginning declined to administer any carbon tetrachloride, no matter from what source, until it has been assayed at the Bureau of Science. The detection of the slightest impurity has invariably led to the redistillation of the drug before its issuance.

We do not wish to be understood as insisting on the administration of carbon-tetrachloride in the comparatively massive doses that we have used. Inspection of our tables will show very clearly that it is quite possible to obtain satisfactory results on a milder basis. Lambert,(6) who has treated 20,000 subjects in Suva, Fiji, reports results that check almost identically with ours as regards the recovery of worms after treatment. He administers 0.2 cubic centimeter of the drug per year of age up to 15 years, giving a uniform dose of 3 cubic centimeters thereafter, irrespective of age or weight. However, on the basis of these and the 25,000 other cases of our own that we cite in this paper, we feel that we have definitely proved that the fears expressed by other workers concerning the toxicity of carbon tetrachloride are largely groundless.

We have selected from our Bilibid group ten men who were successfully treated on a basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight, and have arranged them by weight according to our scale, and also by age, in order to show what they would have received from us according to our method and what they would have received by extending Lambert's age-dosage scale beyond 15 years. It will be seen that only one man would have received a dose beyond the

maximum given by us in this series—a man 70 years of age who would have received 14 cubic centimeters, which dose we already have exceeded by 1 cubic centimeter, with a man in another series, without any ill effects. These figures are set forth in Table 4.

TABLE 4.—*Comparative dosages of carbon tetrachloride as determined by body weight and age.*[a]

Prisoner No.—	Weight.	Our scale.				Extension of Lambert's scale.	
		1 cc. to 5.5 kgm.	1 cc. to 6.0 kgm.	1 cc. to 6.5 kgm.	1 cc. to 7.0 kgm.	Age.	0.2 cc. per year.
	kgm.					*Years.*	
13112	50.0	8.7	8.3	7.6	7.1	48	9.6
14641	40.9	7.4	6.8	6.2	5.8	28	5.6
14642	59.5	10.8	9.9	9.1	8.5	26	5.2
14707	52.7	9.5	8.7	8.1	7.5	29	5.8
14708	62.2	11.3	10.3	9.5	8.8	33	6.6
14709	56.8	10.3	9.4	8.7	8.1	21	4.2
14710	61.6	11.2	10.2	9.4	8.8	45	9.0
14711	45.9	8.3	7.6	7.0	6.5	25	5.0
14713	55.0	10.0	9.1	8.4	7.8	38	7.6
19370	48.1	8.7	8.0	7.4	6.8	70	14.0

[a] Of course, it would be irrational to extend Lambert's scale beyond, say, 21 to 25 years. The figures merely are given as a matter of passing interest.

The average dose of carbon tetrachloride administered to all the men in the series was 8.96 cubic centimeters. The extremes were 6.2 cubic centimeters and 12.5 cubic centimeters, the latter dose having been administered to two men.

Relatively few men escaped some reaction to the drug. The usual symptoms (those we have arbitrarily characterized as "normal") consisted of vertigo and drowsiness. The majority of the men passed into a quiet sleep from which it was not especially difficult to rouse them, within fifteen or twenty minutes after they had taken the drug. This sleep rarely lasted more than an hour or two. Usually most of the men in the different squads were awake when their pulses and blood pressures were taken one hour after treatment, but they usually were quite content to lie still for another hour. Some of the men spoke of vague sensations in the abdomen which we are inclined to regard as the expression of rather vigorous peristaltic movements of the intestine.

Bowel movements, as a rule, began about one to two hours after treatment, and the bowels moved several times within the next twenty-four hours. There was a return to normal

consistence of the stool by the end of the first day following treatment. The first bowel movements were not accompanied by any disturbance, but after two to three hours the drug was prone to leave the intestine in one gush, which occasioned great surprise and some momentary discomfort to the patient.

Occasionally, as a departure from what we have styled the "normal," patients would complain of nausea and vomiting, or excessive thirst, or anorexia, or weakness. Exceptionally, there was abdominal pain, or continued vomiting, or both. Vomiting occurred only in subjects who received 8 cubic centimeters of the drug or more. Only two patients became constipated during treatment. They each were given magnesium sulphate the day following treatment and apparently experienced no ill effects from the prolonged retention of the drug.

At this time it seems appropriate to say something concerning the general hepatic and intestinal reaction to the drug as evidenced by the appearance of the bowel contents after treatment. This bears particularly upon the appearance of bile and mucus in the stools. The detailed observations are recorded in Table 10, which must be consulted for information as to the findings in the individual subjects.

As we have shown elsewhere, carbon tetrachloride exerts a definite stimulating influence upon the liver, and markedly increases the volume of bile discharged into the intestine. Its effects as a cholagogue may be apparent up to the third day after treatment, but as a general rule the bile content of the stool tends to return to normal after the first twenty-four hours.

Stools passed after treatment usually are watery after the contents of the lower bowel have been evacuated. The watery fluid is charged with greater or lesser amounts of bile. Usually, this is dark brown in color, but occasionally stools are passed that are of a brilliant green hue and, if mixed with considerable mucus, bear a resemblance to stools passed by young children who are suffering from disorders of the intestinal tract. We have been unable to determine that an excessive bile content to the stool is associated with any particular symptom or train of symptoms in the subject. We have given carbon tetrachloride to one subject who was jaundiced before treatment, and also have administered it in several cases in which there was definite enlargement of the liver (presumably of malarial origin) without noting any symptoms referable to the liver. In no instance has a subject complained of pain or even discomfort

in the region of the liver. None of our subjects has become jaundiced after treatment.

The local effects of the drug upon the intestinal mucosa are often quite marked. They are expressed by the production of variable amounts of mucus and, as in the effects upon the liver, seem to bear no constant relation to the amount of drug given. Even under the lightest doses mucus is present in the stools, in amounts in excess of that encountered in so-called normal stools. From that point, there is every gradation in quantity up to the point where the bowel discharges consist almost wholly of clear, glairy mucus. In some cases the mucus has a flocculent appearance that resembles the pus seen in bacillary dysentery, but microscopic examination shows it to be devoid of an excess of cellular elements. Excessive secretion of mucus bears no constant relation to abdominal pain after treatment.

In another paper(8) we have mentioned the seeming ill effects brought about by administering a saline purgative immediately before treatment. We suspect that this procedure has a tendency to heighten the intestinal irritation produced by the drug. Preliminary purgation is unnecessary, and we advise against its employment immediately before the administration of carbon tetrachloride. Its effect with the drug seems almost synergistic so far as concerns the production of mucus, for the stools consist wholly of thick, tenacious mucus discharged in great volumes. So voluminous and thick is this mucus that it virtually is impossible to screen the stools. If patients are constipated, it is better to clear the bowel over a period of a day or two by milder methods, and allow the intestine to rest for at least eight or ten hours.

In two instances we have observed the passage of a blood clot from the intestine after treatment. The first case was a young American male with a past history of malaria and bacillary dysentery. He was alcoholic and had drunk Scotch whiskey shortly before taking 8 cubic centimeters of carbon tetrachloride. He slept soundly for about two hours. When he awoke his speech was thick and rambling. In other words he behaved like a man intoxicated with alcohol. He did not feel sick in any way. He was a young man of considerable braggadocio and bravado and immediately consumed a hearty meal of tea and toast, fortunately escaping consequences of this unwise act. Within a few hours he had resumed his normal habits as to alcohol and, except for looseness of the bowels, got along very well until the seventh day, when he passed a small blood

clot. This he brought into the laboratory where it was found to consist entirely of blood. The passage of this clot was not accompanied by any recognizable symptoms, and nothing further developed. It was his third treatment for hookworm infestation, the other two having been carried out with chenopodium, which failed to clear him.

The second case occurred in this series and, of course, was in a Filipino subject. He received 11.7 cubic centimeters of

TABLE 5.—*Reactions of subjects who gave a history of acute or chronic intestinal affections.*

Prisoner No.—	Dose of carbon tetrachloride.	Past intestinal history.	Stool findings after treatment.			General reaction to drug.
			Bile.	Mucus.	Blood.	
	cc.					
13112	8.7	Diarrhœa	—	—	—	Vomited.
14646	7.5	Dysentery for two years	—	—	—	Do.
19189	6.9	do	+	+	—	Normal.
56471	7.7	*Entamœba histolytica* carrier; no dysentery.	+	+	—	Vomited.
14654	9.9	Dysentery	+++	+++	—	Normal.
14656	8.3	Cholera in 1902	—	—	—	Do.
14659	8.6	Dysentery in 1915	+	+	—	Vomited.
14660	10.0	Dysentery in 1911	++	+	—	Do.
14670	8.5	Dysentery in 1921	—	+	—	Normal.
14674	9.1	Typhoid in 1921	+	+++	—	Do.
14676	8.9	Dysentery; cholera	++	++++	—	Do.
14678	11.9	Typhoid	—	++++	—	Do.
14679	8.7	Dysentery in 1920	+	+++	—	Do.
14680	8.4	Cholera in 1908	+	+	—	Do.
14685	9.4	Dysentery	+++	+++	—	Do.
14686	7.5	Dysentery in childhood	—	+	—	Do.
14702	8.1	*Entamœba histolytica* carrier; no dysentery.	+++	+++	—	Do.
14704	7.6	Cholera in childhood	+	+	—	Do.
57342	7.6	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Do.
14711	8.3	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Headache; abdominal pain.
14713	10.0	Cholera and dysentery	—	—	—	Normal.
14723	9.4	*Entamœba histolytica* carrier; no dysentery.	+	+	—	Do.
14727	10.8	Dysentery in 1921	++	++	—	Do.
14728	9.2	*Entamœba histolytica* carrier; no dysentery.	—	+ + +	—	Do.
14730	9.2	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Severe abdominal pain.
19366	11.7	Cholera	—	+ + +	(a)	Normal.
19369	9.8	Cholera; dysentery	—	++	—	Do.
58762	10.0	Dysentery	(b)	(b)	(b)	(b)

[a] Clot. [b] No record.

carbon tetrachloride and got along very well for two days, showing no reaction save a rather large amount of mucus in his stool. Two days after treatment his stool was found to contain free blood and he passed a clot similar to the one passed by the preceding subject. He did not complain of pain or discomfort of any kind and showed no other ill effects. He gave a history of cholera some years previously. He drank tuba in moderation.

These two cases, of course, raise the question of the possible ill effects of carbon tetrachloride on an intestine already weakened by some infectious process. It, therefore, becomes a matter of interest to inquire specifically into the performance of the men in this series, twenty-eight in number, from whom we elicited a history of infectious intestinal affections in the past. The observations on these subjects we have tabulated in Table 5, to admit of ready inspection.

It should be noted that in Table 5 we have not attempted to classify the dysenteries, although it is highly probable that most of them were bacillary in origin. Moreover, it is of passing interest to note that of the seven carriers of *Entamœba histolytica* not one gave a history of dysentery.

The intestinal conditions cited in Table 5 are summarized in Table 6.

TABLE 6.—*Summary of intestinal conditions set forth in Table 5.*

Condition.	Cases.
Cholera	4
Dysentery	11
Dysentery and cholera	3
Diarrhœa	1
Entamœba histolytica carrier (no dysentery)	7
Entamœba histolytica carrier; cholera (no dysentery)	1
Typhoid fever	2

On reviewing the data in Table 5, it will be seen that only two subjects showed any marked general reaction to the drug. Both these men were carriers of *Entamœba histolytica* who gave no history of dysentery. It will be further noted, on comparing the data contained in Tables 5 and 10, that of the men with histories of former intestinal affections, numbering 28 per cent of the total number of men studied, only ten passed excessive quantities (++ to ++++) of mucus in their stools. That number represents 22.7 per cent of the men who passed excessive quantities of mucus after treatment.

In interpreting this, it must be realized that estimations of the relative amounts of mucus in the different stools were not

made on any precise basis. The quantities noted simply are an expression of the judgment of the man who inspected the stools; but they are comparatively accurate.

In conclusion, we feel justified in stating that our observations yield us no information that we consider justifies us in stating that amœbic infection of the bowel wall, or previous dysentery, diarrhœa, cholera, or typhoid fever renders the gut more responsive to whatever irritating properties carbon tetrachloride has than is the uninvolved or undamaged intestine.

The question as to what caused the production of the blood clots in the two cases cited still remains unanswered.

In concluding this section of the paper it should be stated that for many years it has been the rule at Bilibid Prison to administer hookworm treatment to all prisoners when they are admitted and during their period of quarantine before they are finally brigaded. Up to the time this work was started the treatment employed was the administration of thymol. The procedure was looked upon with marked disfavor by the prisoners. So unpopular was it that one of the attendants at the quarantine shed assured us that it was his belief that thymol had kept more men of criminal tendency out of Bilibid than conscience or fear of the law.

After the first squad was treated with carbon tetrachloride we easily could have enlisted the entire population of the quarantine shed for experimental purposes, and we met many requests for treatment from attendants and "trusties" before we finished the work. On one or two occasions it happened that another squad was treated with thymol at about the time one of our groups was undergoing treatment with carbon tetrachloride. The men in our group were quite at ease the following morning, while the other men in the adjoining house were still sustaining the pangs of thymol. Our men gently rallied their less-fortunate fellows much to the amusement of themselves and the onlookers.

OBSERVATIONS ON SUBJECTS SHOWING PHYSICAL DEFECTS

The men in this group may be said to have been fairly representative of the population of the Islands as regards their physical condition. That is to say, they did not present any radical departure as to health and general physical condition from what may be found in any group of Filipinos selected at random. However, the thirty men comprising the group showed some definite pathology when examined before treat-

ment. Eleven exhibited pulmonary disturbances, mainly of a tuberculous nature. There were also some who showed enlargement of the liver or spleen or both, probably of malarial origin. There were some disturbances of the urinary system, some valvular heart lesions, hernias, and the like. Only one or two were frankly sick.

Briefly, it may be stated that none of these men showed any reaction to the drug that differed in any essential form or degree from that shown by men in whom no pathology was detected. Of men showing enlargement of the liver only one was jaundiced, and he suffered no untoward effects from the drug. We were able to detect no influence of the drug on men suffering from valvular disease of the heart or any of the other cardiac irregularities detected by us. All of these cases were studied with particular care. As a matter of fact, twenty-two of these men gave no evidence of any general reaction to the drug.

During treatment of these men, there was a fall in pulse rate in all except two cases, the range being from 6 to 66 beats a minute. The 66-beat fall was due, in all probability, to excitement in the original examination, there being a fall from 130 beats on that occasion to 64 at the time of treatment. There was another, a nonpathologic case, with a pulse rate of 162 at physical examination and 98 on treatment. Neither of these men gave any evidence of cardiac trouble.

Nothing significant was shown by the blood or pulse pressures in these cases. The observations on these men are recorded in Table 7.

TABLE 7.—*Observations on subjects showing physical defects.*

Prisoner No.—	Physical defect.	Dose.	Pulse variation.	Stool.	Urine after treatment.	General reaction.
13112	Active tuberculosis.	8.7	—26	Normal	Granular casts	Vomited.
14641	Liver enlarged; jaundice.	8.9	—28	do	Hyaline casts	Normal.
14643	Valvular lesion heart.	8.3	—10	do	do	Do.
14662	Liver palpable	8.0	—24	do	[a]do	Do.
14663	do	8.9	—32	Mucus, bile	do	Do.
14667	Liver, spleen palpable.	9.0	—14	Mucus	do	Do.
14670	Hydrocœle; hernia.	8.5	—16	do	do	Do.
14672	Old healed tuberculosis.	8.5	—14	Mucus, blood, pus.	do	Nausea and hæmoptysis.

[a] Urine contained casts before treatment.

TABLE 7.—*Observations on subjects showing physical defects*—Continued.

Prisoner No.—	Physical defect.	Dose.	Pulse variation.	Stool.	Urine after treatment.	General reaction.
14675	Pleurisy and adhesions, right lobe.	12.5	—16	Mucus, bile	Hyaline casts	Normal.
14676	Old tuberculosis	8.9	— 6	do	do	Do.
14679	Splenomegaly	8.7	—10	do	Normal	Do.
14689	Liver palpable	7.6	—20	Mucus	Hyaline casts	Do.
14692	do	6.2	—22	Mucus, bile	Trace of albumen, hyaline casts.	Do.
14702	Hernia	8.1	+ 4	do	Hyaline casts	Do.
14707	Active tuberculosis.	9.5	—14	Mucus	[a] Hyaline and granular casts.	Severe headache; vertigo; abdominal pain.
14711	Spleen and liver palpable.	8.3	—19	Normal	Hyaline casts	Headache; abdominal pain.
14712	Acute nephritis	9.3	(?)	Mucus, bile	[b] Albumin pus casts	Severe headache; abdominal pain; vertigo.
14715	Old healed tuberculosis.	10.8	—12	Mucus	Granular casts	Normal.
14721	Splenomegaly	11.1	— 6	Mucus, bile	Normal	Vomited.
14722	do	10.8	— 6	do	do	Fever 100.5°, vertigo; abdominal pain.
14723	do	9.4	—66	do	[a] Hyaline casts	Normal.
14725	do	10.8	—18	do	Hyaline and granular casts.	Do.
14729	Tuberculosis left lung.	9.2	—12	do	do	Do.
14730	Spleen and liver palpable.	9.2	—10	Normal	Trace of albumin; hyaline and granular casts.	Severe abdominal pain.
19188	Old tuberculosis; bronchitis.	7.3	— 8	Mucus, bile	Hyaline casts	Normal.
19369	Valvular heart lesion.	9.8	—20	Mucus	[a] do	Do.
19370	Old healed tuberculosis.	8.7	—46	do	Trace of albumin; hyaline and granular casts.	Do.
57128	Asthma	8.9	+18	Mucus, bile	Hyaline and granular casts.	Do.
57340	Old healed tuberculosis; hernia.	7.1	—34	Mucus	Hyaline casts	Do.
57343	Old tuberculosis	7.1	—10	Mucus, bile	Not examined	Do.

[a] Urine contained casts before treatment. [b] Urine contained albumin before treatment.

ALCOHOLISM AND THE ADMINISTRATION OF CARBON TETRACHLORIDE

A question always arises as to the wisdom of administering carbon tetrachloride to a person of known alcoholic habits who presents himself for the treatment of hookworm infection. Admittedly the association of the drug with alcohol is fraught

with a certain amount of risk, especially in the case of the constant and heavy drinker. Our study of these cases, however, has led us to the belief that the drug may be administered with perfect safety to persons who indulge moderately in alcoholic drinks, provided they are willing to forego them for three or four days prior to taking the drug. We are of the opinion, however, that carbon tetrachloride should be given with the utmost caution to those who drink habitually to the point of intoxication, and it also should be withheld from those who are not willing to abstain from alcohol for a few days before and after treatment.

Lambert(6) says that alcoholism is a contraindication and that liquor should not be taken for "several hours" before and after treatment. We prefer to err on the side of prudence, however, and withhold alcohol from our patients for three or four days prior to treatment.

Notwithstanding we have treated many persons who have admitted the use of alcohol in a moderate degree, and several who were not so abstemious, we have been able, by withdrawing alcohol for the time stated, to avoid the untoward effects that show themselves in alcoholics. However, we have noted the effects of disregard of this precaution in men treated by practicing physicians.

One case was afforded by an American business man whose daily regimen included several glasses of "Scotch and soda," but who could not be classed as a drunkard. Following the finding of hookworm ova in his stools, he was referred to his physician, who had treated several patients with carbon tetrachloride and was quite familiar with the contraindications to its use. Unfortunately he failed to caution his patient.

So the man attended a business luncheon, indulging in two cocktails and a heavy course meal. Later in the afternoon he partook of four Scotch and sodas and shortly afterwards drank 8.5 cubic centimeters of carbon tetrachloride. He was violently nauseated at intervals during the night and his bowels moved freely. The following day he became markedly jaundiced and very weak, and the jaundice persisted for two days, after which he recovered and showed no further ill effects except a marked distaste for carbon tetrachloride.

The second case was presented by a Spaniard engaged in business in the provinces who contracted a hookworm infestation that gave rise to a marked anæmia. He had an eosinophilia of 11 per cent. He was treated by his family physician and

gave the following performance, the notes on which were furnished by his physician:

August 4. Calomel, 3 grains at bedtime.

August 5. Epsom salts in morning. Liquid diet.

August 6. No breakfast. Nine cubic centimeters of carbon tetrachloride given at 9 a. m.

Two hours after taking the medicine his bowels began to move, and the purging continued all day. His chief complaint was a burning sensation at the anus. Many worms were recovered, but no count was made.

August 7. The patient complained of pain in the stomach. He vomited many times during the day and night, the vomitus containing mucus and bile.

August 8. The patient vomited frequently during the day. In the evening he was given a hypodermic of pantopon. He slept well and had no recurrence of the pain or the vomiting.

August 9. The patient became markedly jaundiced. His urine was very dark, containing bile, but no albumin, sugar, or casts.

August 12. Discharged from the hospital. The jaundice was beginning to fade. His appetite was good.

The patient was instructed to report again in two weeks for another stool examination, but he failed to do so. However, his friends stated that he was gaining in weight and had a ravenous appetite. He went back to his work in the provinces.

Particulars regarding the extent of the alcoholic indulgences of this man were not forthcoming, but there seems little reason to doubt, from such information as we could secure, that his troubles were consequent upon a too-close association between alcohol and carbon tetrachloride.

These are two fairly extreme cases. Others we have seen were milder, but all recovered and showed no outward effects after convalescence. Obviously, the drug had spent considerable force on the liver in every case and there is, of course, no means of telling at the present time if the damage wrought was of a permanent nature.

Nothing of this kind occurred among our prisoners, however. Statistically, so far as abnormal reactions following treatment are concerned, our "alcoholic group" made a distinctly better showing than did those who denied the use of liquor. Out of the entire group, forty-eight men asserted that they used alcohol in moderation, while two admitted that they used it in excess. Fifty-five of the men denied the use of alcohol in any form, while five failed to make a statement either way. None of these men were whiskey drinkers. A few drank beer, but most of them indulged in tuba, which is quite freely drunk in some of the rural districts. None of the men had tasted liquor in any form for at least a week prior to treatment.

Preliminary to a discussion of the observations made on these men, we present Table 8, which summarizes the reactions in the alcoholic and nonalcoholic groups.

TABLE 8.—*Résumé of reactions in subjects admitting and denying the use of alcohol.*

Symptom.	Use of alcohol—			
	Admitted.		Denied.	
	Number.	*P. ct.*	*Number.*	*P. ct.*
Vomiting	3	7.5	10	18.0
Blood and pus in stool [a]	2	5.0		
Blood clot in stool	1	2.5		
Abdominal pain	2	5.0	3	5.4
Abdominal pain and vomiting	1	2.5		
Bile and mucus in stool	25	62.0	28	50.0
Bile in stool	1	2.5	4	7.2
Mucus in stool	10	25.0	7	12.7
No abnormal reaction	32	80.0	35	63.6

[a] Study of the cellular exudate in the stools of these men indicates that they were suffering from mild bacillary dysentery.

With the foregoing table as an introduction, we shall now consider these various reactions in terms of the proportionate amounts of the drug administered to the different men. To do this we shall assemble the subjects into four groups on the above basis. This classification, besides being in conformity with the plan followed by us in regulating the dosage for the different subjects, admits of clearer analysis than any other method. The four groups consist of—

1. Men receiving 1 cubic centimeter of carbon tetrachloride to each 7 kilograms of body weight.
2. Men receiving 1 cubic centimeter to each 6.5 kilograms of body weight.
3. Men receiving 1 cubic centimeter to each 6 kilograms of body weight.
4. Men receiving 1 cubic centimeter to each 5.5 kilograms of body weight.

Table 9 shows the average dose received by the men in each group as well as the extremes.

TABLE 9.—*Average actual dose and range of dose of carbon tetrachloride as calculated on basis of kilograms of body weight.*

One cubic centimeter to each—	Subjects.	Average dose.	Range of dosage.	Average weight.
		cc.	*cc.*	*Kg.*
7 kilograms body weight	25	7.7	6.2– 9.4	54.5
6.5 kilograms body weight	9	7.8	6.9– 9.4	51.3
6 kilograms body weight	29	9.1	8.0–12.5	55.0
5.5 kilograms body weight	33 (37)	10.0	8.3–12.5	55.0

The reactions of the individual men in the four groups are set forth in Table 10.

TABLE 10.—*General reaction of alcoholic and nonalcoholic subjects following treatment with carbon tetrachloride.*

GROUP 1. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 7 KILOGRAMS OF BODY WEIGHT.

Prisoner No.—	Alcohol.	Stool findings.		Actual dose.	General reaction.
		Mucus.	Bile.		
				cc.	
14680	Tuba, moderate	+	+	8.4	Normal.
14681	Denied	+	+	9.0	Do.
14682	do			6.6	Do.
14683	do	+	+	8.3	Weak and unable to walk two days after.
14684	do			6.6	Normal.
14685	Beer, moderate	+++	+++	9.4	Gas; otherwise normal.
14686	Tuba, moderate	+		7.5	Normal.
14687	do	+++	+++	9.4	Do.
14689	Denied	+		7.6	Do.
14690	do	+	+	8.7	Do.
14691	do	+	+++	9.0	Do.
14692	Tuba, moderate	+	+	6.2	Do.
14693	Denied	+++	+	7.1	Do.
14694	do	+	+++	7.5	Do.
14695	do	+	+++	6.2	Do.
[a] 14702	Tuba, moderate	+++	+++	8.1	Do.
14703	do	+		8.2	Do.
14704	do	+	+	7.6	Do.
[a] 14705	Denied	++	++	7.8	Do.
57340	Tuba, moderate	+		7.1	Do.
57341	Denied	+++	+++	8.3	Do.
[a] 57342	Tuba, moderate			7.6	Do.
57343	do	+++	+++	7.1	Do.
[a] 57345	Denied		+++	6.2	Do.
57346	Tuba, moderate	+++	+++	7.8	In hospital from other causes; pain in stomach after treatment.

[a] Hookworm ova found after treatment.

GROUP 2. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 6.5 KILOGRAMS OF BODY WEIGHT.

14579	Denied			8.1	Normal.
14646	do			7.5	Vomited after eating.
19188	do	++	++	7.3	Normal.
19189	do	+	+	6.9	Do.
56471	Beer, moderate	+	+	7.7	Vomited after water.
57128	Denied	+++	+++	8.9	Normal.
57129	do	+++	+++	9.4	Do.
57139	do		+++	7.7	Do.
57140	do			7.1	Do.

GROUP 3. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 6 KILOGRAMS OF BODY WEIGHT.

11389	Denied			8.8	Normal.
14643	do			8.3	Do.
14654	do	+++	+++	9.9	Do.
14656	do			8.3	Do.
14657	do	++	++	10.0	Do.
14658	do		+	10.4	Do.
14659	do	+	+	8.6	Vomited.
14660	do	+	++	10.0	Do.
14661	Moderate		+	9.9	Gas; no other trouble.
14662	Denied			8.0	Normal.
14663	Moderate	++	+	8.9	Gas; no other trouble.
14664	Denied	+++	+++	8.0	Normal.
14666	Tuba, moderate	++	++	8.6	Do.
14667	Denied	++++		9.0	Do.
14668	Excess	+	+	8.3	Frequent and painful, bloody, mucoid stools; probably bacillary dysentery.
14669	Denied	+	+	9.3	Normal.
14670	Tuba, moderate	+		8.5	Do.
14671	do	+++	+++	9.8	Do.
14672	do	+		8.5	Nausea five days; blood and pus in stool; probably bacillary dysentery; hæmoptysis; tuberculosis.
14673	Denied	+	+	9.1	Normal.
14674	Tuba, moderate	+++	+	9.1	Do.
14675	do	+++	+	12.5	Do.
14676	Tuba excess	++++	++	8.9	Gas; no other trouble.
14677	Denied	+++	+	8.3	Normal.
14678	Tuba, moderate	++++	++	11.9	Do.
14679	Denied	+++	+	8.7	Do.
19174	do			8.8	Slight vomiting.
57112	do			8.0	Normal.
57600	do			8.1	Slight vomiting after food.

GROUP 4. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 5.5 KILOGRAMS OF BODY WEIGHT.

13112	Denied			8.7	Vomited.
14641	do			8.9	Normal.
14642	do			10.8	Vomited.
14707	do	+++		9.5	Severe headache and vertigo; abdominal pain.
14708	Moderate	+	+	11.3	Normal.
14709	Denied	+	+++	10.3	Do.
14710	do	++	+++	11.2	Pain in stomach, twelve hours.
14711	Tuba, moderate			8.3	Headache and abdominal pain.
14712	Denied	+	+	9.3	Severe headache and vertigo; abdominal pain.

GROUP 4. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 5.5 KILOGRAMS OF BODY WEIGHT—Continued.

14713	Denied	+	+	10.0	Normal.
14714	do	+++		9.0	Vomited.
14715	do	++		10.8	Normal.
14717	do		+++	10.0	Do.
[a] 14718	do	+++	+++	12.0	Do.
14719	do	+	+++	9.4	Vomited.
14721	Tuba, moderate	+	+	11.1	Do.
14722	do	+	+	10.8	Fever 100.6°; vertigo; abdominal pain, one hour after treatment.
[a] 14723	do	+	+	9.4	Normal.
14724	do	+		9.4	Do.
14725	do	+++	+++	10.8	Do.
[a] 14726	Gin and tuba moderate	+		8.9	Do.
14727	do	++	++	10.8	Do.
14728	Tuba, moderate	+++		9.2	Do.
14729	do	+	+	9.2	Do.
[a] 14730	do			9.2	Severe abdominal pain, one hour after treatment.
14731	do	+	+	8.7	Normal.
14733	do	+		11.6	Do.
14966	No record			8.7	No record.
14969	do	+++		12.5	Do.
15001	do			10.4	Do.
19180	Denied			10.8	Vomited.
[b] 19366	Moderate	+++		11.7	Normal.
19367	No record	+	+	9.3	Do.
19369	Denied	++		9.8	Do.
19370	do	+		8.7	Do.
57127	Tuba, moderate			11.4	Do.
58762	No record			10.0	No record.

[a] Hookworm ova found after treatment.

[b] This patient passed a blood clot from the intestine after treatment.

Unfortunately, a wide numerical discrepancy exists between the subjects composing group 2 (the 6.5-kilogram group) and the other three groups; nevertheless, the comparative figures are interesting. This interest is aside from the question of whether the men were or were not alcoholic; for by this time it will be seen that, if anything, the "alcoholics" appear to have the best of the bargain so far as concerns immunity to the effects of the drug. Aside from the second group, already mentioned, it will be seen that the other three groups afford a good basis of discussion of the effects of a drug administered on the kilogram-of-body-weight basis, because the average weights of the men in each group are practically identical. The second group, containing only nine men, does not afford a good basis for comparison.

To begin: The first group of twenty-five subjects, having an average weight of 54.5 kilograms, received an average dose of carbon tetrachloride amounting to 7.7 cubic centimeters, calculated on a basis of 1 cubic centimeter of the drug to each 7 kilograms of body weight. None of the men in this group vomited. In fact, only two men showed reactions barely over the threshold of those we have arbitrarily designated as "normal." On a liberal interpretation, therefore, we state that 4 per cent of the men in this group showed slightly unpleasant symptoms.

The second group of men, nine in number, of an average weight of 51.3 kilograms, received an average dose of 7.8 kilograms of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 6.5 kilograms of body weight. By referring to Table 9, it will be seen that the average dose and the range of dose show very little variation over those of the preceding group, which taken with the numerical strength of the group makes clear the fallacy involved in the 22 per cent abnormal reactions we are forced to charge against the two men who vomited after treatment.

A more satisfactory basis of calculation is afforded by the third group. This consisted of twenty-nine men, whose average weight was 55 kilograms, and who received an average dose of 9.1 cubic centimeters of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 6 kilograms of body weight. Six of these men were sick after treatment, but we feel that only four of the reactions should be charged against the drug. Two of the men passed stools that contained blood, pus, and mucus thirty-six hours after treatment, at which time they had wholly recovered from the very slight reaction they exhibited to the drug. On careful study of stained preparations made from these stools, we are convinced that these two men suffered a slight exacerbation of bacillary dysentery which bore no direct relation, at least, to the treatment. The other four men had vomiting of varying degrees of severity probably largely the result of eating too heavy a meal four or five hours after the drug was administered, but exhibited no other ill effects. Therefore, we record 14 per cent of symptoms above our normal in this group.

The fourth and final group consisted of thirty-seven men; but, as the records are imperfect in certain particulars in four instances, we have figured on a basis of thirty-three men. The average weight of the men in this group was 55 kilograms,

and they received an average dose of 10 cubic centimeters of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight. Eleven of these men, or 33.3 per cent, showed abnormal reactions. Many of these reactions were more pronounced than those shown by the men in the other groups. One man complained of severe pain in the stomach; five vomited; and five complained of severe headache, vertigo, and abdominal pain. Another man passed a blood clot in his stool two days after treatment, but he showed no symptoms of ill effects at any other time.

To summarize, it will be seen that 18.7 per cent of the men in the series from whom we secured complete data showed clinical reactions to the drug that may be regarded as approaching the undesirable. In no case, however, did symptoms of an alarming nature supervene, and the disturbances in all cases were purely transitory. It should be especially noted that 61.1 per cent of those showing abnormal reactions were men in the fourth group, who received treatment on a basis of 1 cubic centimeter of carbon tetrachloride to each 5.5 kilograms of body weight. We are not disposed to argue the point with those who may assert that such a dose is in excess of the amount required to dislodge the worms. We think it highly probable that such a dose is not necessary in the majority of instances. The point we wish to emphasize, however, is that this dose is perfectly safe *provided the drug is of established purity and no physical contraindications exist in the patient.*

In support of the above statement, we feel that it is opportune to state at this time that within the past few months there have been treated on Cebu Island, under the supervision of Dr. Cristobal Manalang, of the Philippine Health Service, more than 25,000 hookworm-infested Filipinos of both sexes and all ages. Working under our direction, Doctor Manalang has administered the drug on the basis of 1 cubic centimeter to each 5.5 kilograms of body weight. There have been no deaths, and in no case have toxic symptoms of any moment arisen. Every liter of the drug used in Cebu, before being shipped there, was subjected to careful test and refinings at the Bureau of Science, under supervision of Mr. Wells. Finally, it must be stated that a large proportion of the residents of Cebu drink freely of tuba, and it is extremely likely that a large number of these drank tuba within relatively short periods before undergoing treatment.

Regarding the relative efficacy of the drug in the proportions administered in these four groups, it is to be noted that four

men in the first group showed hookworm ova in their fæces several weeks after treatment, and five men also were positive in the fourth group on reëxamination. The men in the middle two groups all were microscopically negative when their fæces were reëxamined.

Two facts, therefore, are made plain by the foregoing, namely:

1. Carbon tetrachloride may be safely given in a proportion of 1 cubic centimeter to each 5.5 kilograms of body weight, up to an actual dose of 12.5 cubic centimeters. It will be seen by Table 10 that symptoms of an abnormal nature bear no real relation to the actual amount of the drug taken, for they are as likely to arise following the administration of the smaller amounts as of the larger volumes.

2. Moderate alcoholism is no contraindication to the use of carbon tetrachloride, provided liquor is withheld from the patient for several days before and after treatment, and provided there is no involvement of the liver or alimentary tract.

THE URINE

In the study of these men we obtained no evidence that would indicate that carbon tetrachloride, administered in doses ranging from 6.2 to 12.5 cubic centimeters, exerts a deleterious effect on the kidneys that is more than transitory. In only two subjects was albumin detected after treatment where it had not already been found before treatment. In three instances albumin was found before treatment, but not afterwards, and in four other cases albumin was present both before and after treatment.

In one instance we administered 9.3 cubic centimeters of the drug to a man (prisoner 14712) who showed definite evidence of renal disturbance. During treatment this man complained of severe headache and abdominal pain, but the phenomena differed in no way from those shown by several men exhibiting the same symptoms, after treatment, but whose kidneys appeared to be clear. Before treatment, this man's urine was strongly positive for albumin; it contained also leucocytes and erythrocytes. Forty-eight hours after treatment, the albumin reaction was even stronger, and many leucocytes and hyaline and granular casts were present. Physically, however, the man seemed no worse during the period he was under observation.

The occurrence of casts (hyaline and granular) was frequent, however. Forty-two of the men had casts in their urine after treatment, though none had been detected before. Casts were present both before and after treatment in twenty-five subjects,

and before treatment, only, in seven others. In passing, it may be remarked that we have observed that hyaline and granular casts are of frequent occurrence, without an associated albuminuria, in a large proportion of Filipinos who are in apparently normal health, so that undue significance should not be placed on these findings.

The urine of many of the men showed a tendency to assume a darker hue immediately after treatment. However, in only one instance was a test for bile positive. This was the case of prisoner 14704, who received 7.6 cubic centimeters of carbon tetrachloride, on the basis of 1 cubic centimeter to each 7 kilograms of body weight. His urine was negative for albumin and casts, both before and after treatment. It was very dark in color after treatment and of a specific gravity of 1.026. Leucocytes in small numbers were present, both before and after treatment.

This man showed no physical reaction to the drug, and the watery stools passed by him contained only small quantities of bile and mucus. His liver was not palpable. He did not become jaundiced.

We have not undertaken to analyze the other data obtained by urinalysis, because standards bearing on the routine clinical examination of Filipino urine are not available. We would say, parenthetically, that we encountered nothing that we are inclined to regard as especially significant to this study. The pathological findings in the urines made by us are recorded in Table 11.

THE BLOOD

Notwithstanding the study of the blood of these subjects was carried out with all the care and thoroughness possible under the methods employed, the data collected are almost too bizarre to be treated in detail. However, we feel justified in drawing certain conclusions on the basis of our blood findings.

A large proportion of subjects showed a distinct polycythæmia and high hæmoglobin percentage. Such conditions in a group of men known to harbor hookworm naturally awakened our interest. However, it is, in a large measure, explained by the low worm counts, more than 90 per cent of which were below 100.

The total erythrocyte counts of seventy-four of the subjects showed 5,000,000 or more erythrocytes per cubic millimeter. Of these, eighteen men showed a count of above 6,000,000, and six men above 7,000,000 erythrocytes. Hæmoglobin estima-

TABLE 11.—*Urine, before and twenty-four hours after treatment; cases showing albumin, casts, or both.*

Prisoner No.—	Dose.	Before treatment.		After treatment.	
		Albumin.	Casts.	Albumin.	Casts.
	cc.				
13112	8.7				Few granular.
14641	8.9				Occasional hyaline.
14642	10.8				Do.
14643	8.3				Do.
14646	7.5				Do.
19174	8.8				Do.
57600	8.1				Do.
19188	7.3				Hyaline.
56471	7.7				Do.
57112	8.0	+		Faint trace	Granular.
57127	11.4		Granular		Occasional hyaline.
57128	8.9				Long hyaline; few granular.
57129	9.4			Trace	Occasional hyaline.
14654	9.9		Occasional hyaline		None.
14656	8.3				Few hyaline.
14657	10.0		Hyaline		Hyaline.
14658	7.4		do		Do.
14659	8.6				Do.
14661	9.9		Hyaline		Do.
14662	8.0		do		Do.
14663	8.9				Hyaline and granular.
14664	8.9			+	Few short hyaline
14666	8.6	+		+	
14667	9.0				Few hyaline.
14669	9.3				Hyaline.
14670	8.5				Many short hyaline.
14671	9.8		Few hyaline		None.
14672	8.5		do		Few hyaline.
14673	9.1		Occasional hyaline		None.
14674	9.1		Hyaline		Hyaline.
14675	12.5		do		Do.
14676	8.9		do		Do.
14677	8.3				Occasional hyaline and granular.
14678	11.9				Occasional hyaline.
14680	8.4		Occasional hyaline		Numerous hyaline.
14681	9.0				Occasional hyaline.
14683	8.3		Occasional hyaline		Do.
14684	6.6				Do.
14685	9.4		Occasional hyaline		Negative.
14687	9.4				Few hyaline.
14689	7.6				Occasional hyaline
14690	8.7		Hyaline and granular		Hyaline.
14691	9.0				Occasional hyaline.
14692	6.2			Slight trace	Do.
14693	7.1				Do.

TABLE 11.—*Urine, before and twenty-four hours after treatment; cases showing albumin, casts, or both*—Continued.

Prisoner No.—	Dose.	Before treatment.		After treatment.	
		Albumin.	Casts.	Albumin.	Casts.
	cc.				
14694	7.5	+		(?)	Hyaline.
14695	6.2		Hyaline		Do.
[a] 14702	8.1				Occasional hyaline.
14705	7.8				Do.
57340	7.1	Trace		Negative	Do.
57342	7.6		Hyaline		Hyaline.
57345	6.2		Few hyaline		Few hyaline.
57346	7.8			Trace	
14707	9.5		Occasional hyaline	Faint trace	Few hyaline and granular.
14708	11.3	+	Few hyaline and granular.	Trace	Negative.
14709	10.3		Occasional small hyaline.		None.
14710	11.2		Granular	Faint trace	Occasional hyaline.
14711	8.3				Do.
[b] 14712	9.3	+		+++	Many short hyaline and granular.
14713	10.0				Occasional hyaline.
14714	9.0		Many		Few large hyaline.
14715	10.8				Few granular.
14718	12.0		Few		None.
14723	9.4		Occasional hyaline		Occasional hyaline.
14724	9.4		Number of hyaline		Few hyaline.
14725	10.8				Large number of hyaline and granular.
14726	8.9	+	Many granular; few hyaline.	Trace	Few hyaline and granular.
14727	10.8	Slight trace	Few	Negative	Great number of hyaline and granular.
14728	9.2				Occasional hyaline.
14729	9.2	Trace		Negative	Hyaline and granular.
14730	9.2			Trace	Few hyaline and granular.
14731	8.7		Hyaline		Great number of hyaline and granular.
14733	11.6	+		Negative	Few hyaline.
19367	9.3		Occasional hyaline		Occasional hyaline.
19369	9.8		Few granular		Few hyaline.
19370	8.7			Slight trace	Few hyaline and granular.
58762	10.0	Trace		Not done	Not done.

[a] Urine contained bile after treatment.

[b] Urine also contained mucus, leucocytes, and erythrocytes before treatment, and leucocytes after treatment in addition to the other elements noted.

tions of 90 per cent or more were made on fifty-nine men. In only two cases were low erythrocyte counts and hæmoglobin estimations associated with worm counts of 100 or more, as is shown by Table 12. Particular attention is drawn to case 14658 in that table, in which the highest worm count is seen to be associated with the highest erythrocyte count and one of the highest hæmoglobin estimations. On screening the stools of this man 1 *Ancylostoma* and 354 *Necator* were recovered.

TABLE 12.—*Total erythrocyte counts and hæmoglobin estimations in nine subjects from whom 100 or more hookworms were recovered after treatment.*

Prisoner No.—	Worm count.	Erythrocytes.	Hæmoglobin.
			Per cent.
14726	100	4,050,000	45
14702	121	5,450,000	85
14705	149	5,500,000	88
57342	148	4,850,000	58
57345	303	3,900,000	35
14642	118	5,360,000	88
14659	244	4,720,000	93
14680	154	5,500,000	85
14658	355	6,130,000	88

It is difficult to say whether or not these high erythrocyte counts are due to increased oxidation in the Tropics. On the other hand, it should be noted that these counts were made during the month of May, which is the height of the hot, dry season in Manila, in consequence of which there may be an association between the polycythæmias and a decreased fluid content of the blood. These are points that can only be determined by extensive investigation. It is suggestive of a lack of reaction, or a failure on the part of the subject to experience serious effects from the presence of intestinal parasites. Only four of the men had erythrocyte counts that fell below 4,000,000, and only a like number exhibited a hæmoglobin percentage that fell below 70.

These figures are startlingly at variance with those we obtained on study of the blood of eleven cases of hookworm anæmia in Cebu.(8) In that series the total erythrocyte counts ranged from 1,380,000 in a heavily infected case, up to 3,330,000 in a case that already had been treated with chenopodium but still retained a light infection. In the Cebu series the hæmoglobin

percentages ranged from a point below the 10 per cent mark on the Tallquist scale up to 70. The total erythrocyte counts and hæmoglobin estimations made before treatment are summarized in Tables 13 and 14.

TABLE 13.—*Distribution of total erythrocyte counts before treatment.*

Erythrocytes per cubic millimeter.	Subjects.
3,000,000 and over	4
4,000,000 and over	22
5,000,000 and over	50
6,000,000 and over	18
7,000,000 and over	6

TABLE 14.—*Hæmoglobin estimations before treatment.*

Hæmoglobin. Per cent.	Subjects.
90–100	59
80–89	34
70–79	3
60–69	1
50–59	1
40–49	1
30–39	1

Relatively little work has been done on the red elements of the blood of Filipinos, but our findings are in substantial agreement with those of other observers who have dealt with similar subjects. On differential leucocyte counts we recorded an average of 51 per cent polymorphonuclear neutrophiles. Guerrero and Sevilla(3) report an average of 51.6 in their series, and Chamberlain(1) a range of from 47 to 52 per cent in his various series of Filipinos.

After treatment, we noted a tendency toward a rise in the proportion of polymorphonuclear neutrophiles during the first twenty-four hours following the administration of the drug. A varying degree of increase was noted in fifty-eight of the men. This effect, however, was not permanent, for after a period of about two months only thirty-eight of the men showed a continued elevation above the count made before treatment.

Perhaps the most striking feature of the blood picture was the practically universal eosinophilia. This is set forth in Table 15, in which the eosinophile counts are associated with the hookworm counts. It will be seen that the correlation is very loose. It may be mentioned, in passing, that no skin affections existed among these men that would influence the eosinophile count. One man gave a history of asthma. He had 10 per cent

eosinophiles at the first examination which had fallen to 6 per cent three and one-half months later. We recovered seven *Necator* after treating him.

TABLE 15.—*Relation of eosinophilia to number of hookworms recovered after treatment.*

[A = *Ancylostoma duodenale.* N = *Necator americanus.*]

Prisoner No.—	Hookworms recovered.	Eosinophilia.			Interval between counts.		Differential worm counts.
		Before.	After.	Differences.			
		Per cent.	*Per cent.*	*Per cent.*	*Months.*	*Days.*	
14641	69	14.0	2.5	—11.5	3	21	4 A, 65 N.
14642 [a]	118	27.0	8.5	—18.5	3	21	32 A, 86 N.
14646	9	18.5	3.5	—15.0	3	15	
19180	8	7.0	2.0	— 5.0	3	21	
19188	12	4.5	4.0	— 0.5	3	17	
57127	23	5.0	5.0	— 0.0	3	21	
57129	0	10.0					
57140	12	9.0					
14654	23	3.5					
14656	2	0.5					
14657	31	7.0					
14658	355	5.0					
14659	244	4.5	5.5	+ 1.0	3	11	
14660	38	5.5	6.5	+ 1.0	3	11	
14661	18	6.5	4.0	— 2.5	3	8	
14662	70	4.5	5.5	+ 1.0	3	8	
14663	10	8.0					
14664	4	6.5	2.5	— 4.0	3	8	
14666	0	10.5	7.0	— 3.5	3	8	
14667	9	6.0					
14668	73	26.5					29 A, 34 N.
14669	6	10.0	7.0	— 3.0	3	6	
14670	24	18.5	4.0	—14.5	3	6	4 A, 20 N.
14671	8	7.5	12.0	+ 4.5	3	7	
14672	7	11.5	10.0	— 1.0	3	7	
14673	9	10.5	7.0	— 3.5	3	7	
14674	44	4.0	22.0	+18.0	3	2	20 A, 24 N.
14675	13	5.5	10.0	+ 4.5	3	2	
14676	19	14.0	8.0	— 6.0	3	2	
14677	56	27.5	9.0	—18.5	3	2	19 A, 37 N.
14678	1	6.5	16.0	+ 9.5	3	2	
14679	2	3.0	2.0	— 1.0	3	2	
14680	154	10.0	13.0	+ 3.0	2	21	8 A, 146 N.
14681	0	10.0	18.0	+ 8.0	2	21	
14682	2	5.5	9.0	+ 3.5	2	21	
14683	3	12.5	6.5	— 6.0	2	21	
14684	0	9.5	6.5	— 3.0	2	21	
14685	11	7.0	10.0	+ 3.0	2	21	
14686	26	10.5	1.0	— 9.5	2	21	14 A, 12 N.
14687	2	11.5	10.0	— 1.5	2	21	

[a] Hookworm ova found after treatment.

TABLE 15.—*Relation of eosinophilia to number of hookworms recovered after treatment*—Continued.

Prisoner No.—	Hookworms recovered.	Eosinophilia.			Interval between counts.		Differential worm counts.
		Before.	After.	Differences.			
		Per cent.	*Per cent.*	*Per cent.*	*Months.*	*Days.*	
14689	72	16.5	0.0	—16.5	2	18	10 A, 62 N.
14690	16	17.0	11.5	— 5.5	2	18	2 A, 14 N.
14691	17	8.0	4.0	— 4.0	2	18	5 A, 12 N.
14692	16	5.5	3.5	— 2.0	2	19	3 A, 13 N.
14693	9	6.5	7.0	— 0.5	2	19	
14694	0	6.5	1.0	— 5.5	2	19	
14695	2	3.5	2.0	— 1.5	2	19	
14702 [a]	121	5.0	22.0	+17.0	2	19	11 A, 110 N.
14703	22	7.0	5.0	— 2.0	2	-------	
14704	13	6.5	-------	-------	-------	-------	
14705 [a]	149	23.0	18.0	— 5.0	2	16	12 A, 137 N.
57340	0	11.0	-------	-------	-------	-------	
57341	98	14.0	10.0	— 4.0	2	16	36 A, 62 N.
57342 [a]	148	11.0	33.0	+22.0	2	16	6 A, 142 N.
57343	56	13.0	-------	-------	-------	-------	19 A, 37 N.
57345 [a]	302	9.5	31.0	+21.5	2	16	32 A, 270 N.
57346	1	7.5	12.0	+ 4.5	2	16	
14707	78	16.5	9.0	— 7.5	2	8	78 N.
14708	91	19.0	9.0	—10.0	2	8	91 N.
14709	5	12.0	7.5	— 4.5	2	8	5 A.
14710	0	9.0	10.0	+ 3.0	2	8	
14711	4	15.5	6.5	— 9.0	2	8	
14712	26	13.0	16.0	+ 3.0	2	8	26 A.
14713	25	8.5	3.5	— 5.0	2	9	
14714	2	22.0	4.0	—18.0	2	9	
14715	21	16.5	8.0	— 8.5	2	6	
14717	16	7.5	7.5	0.0	2	6	
14718 [a]	43	6.5	7.5	— 1.0	2	6	
14719	9	3.5	7.0	+ 3.5	2	6	
14721	7	25.5	17.0	— 8.5	2	6	7 N.
14722	2	14.0	4.0	—10.0	2	6	2 N.
14723 [a]	9	21.5	0.0	—21.5	2	6	7 A, 2 N.
14724	7	10.5	7.5	— 3.0	2	4	3 A, 4 N.
14725	30	14.0	9.0	— 5.0	2	4	8 A, 22 N.
14726 [a]	100	1.5	12.0	+10.5	2	4	23 A, 77 N.
14727	97	24.0	12.5	—11.5	2	4	27 A, 50 N.
14728	24	14.5	8.5	— 6 0	2	4	5 A, 19 N.
14729	46	24.0	3.0	—21.0	2	4	9 A, 37 N.
14730 [a]	22	16.5	1.5	—15.0	2	4	2 A, 20 N.
14731	37	12.5	3.0	— 9.5	2	4	16 A, 21 N.
14733	10	21.5	2.5	—19.0	2	4	6 A, 4 N.
19366	97	5.5	-------	-------	-------	-------	49 A, 48 N.
19367	15	10.5	-------	-------	-------	-------	14 A, 1 N.
19369	7	1.0	-------	-------	-------	-------	
19370	12	2.0	-------	-------	-------	-------	

[a] Hookworm ova found after treatment.

Assuming 4 per cent as a liberal normal high eosinophile count, only nine cases will be seen to present a normal eosinophilia. A number of very high counts were found, the highest being 33 per cent. Ten of the counts made before treatment were above 20 per cent.

This is in sharp contrast to the blood picture presented by the group of subjects in Cebu who were suffering from advanced hookworm disease, recently studied by us,(8) in which the anæmia was profound and in none of whom did we find an eosinophile count above 7 per cent.

In the majority of the subjects infested with hookworm, there was a distinct lowering of the eosinophiles during the two months following treatment. This was particularly noticeable in many of the cases that showed a high percentage of eosinophiles on the initial count. In subjects who gave low original counts, there are a few instances in which a rise is recorded. In some of these instances, it will be seen that microscopic examination had shown the men to have retained their infections after treatment. Some of these persistent positives may have been men in whom an infection was developing at the time of their admission to the prison, for they came into our hands almost immediately after commitment. It also must be borne in mind that very few of the men were cleared of their entire helminthal infection, *Ascaris* and *Trichuris* persisting in many cases. Nevertheless, twenty-five of the examinations made two months after treatment show a normal eosinophilia (4 per cent or less). The highest percentages were found in those still retaining hookworms.

HOOKWORM DISEASE

None of the subjects studied in this series presented a clinical picture that could be regarded as one of extreme hookworm disease. In fact, practically 90 per cent of the men showed no symptom that could be attributed to hookworm infestation. Moreover, in the cases in which we were inclined to suspect the presence of hookworm anæmia the improvement in the blood picture and general physical condition of the men must be interpreted with considerable caution, as we shall show by the cases of two uninfected men. It must be borne in mind that nearly all the men studied were drawn from the lower walks of life and presented the familiar undernourished condition that is characteristic of natives of Malaysia. In the group of nine men, protocols of whose cases we shall give below, eight were laborers.

All these men, before entering the prison, lived on the staple diet of the country—fish and rice—and probably not too much of either. It is scarcely necessary to add that their surroundings were insanitary and their manner of living distinctly unhygienic. Within the prison, however, their entire mode of life was changed. They received a simple but well-balanced ration, which included a liberal allotment of meat, in which most of them had not habitually indulged in the past. Their hours of work and rest were regular, and they were put through setting-up drills and allowed time for healthy recreation. Moreover, their surroundings were strictly sanitary. Under such circumstances it is a little difficult to make any general statement respecting the effects of treatment on men who originally were below par physically.

In illustration of this point we present the protocols of the two subjects who were not infested with hookworms.

Prisoner 13112.—Aged 48 years. Laborer. Symptoms of pulmonary tuberculosis. Microscopic examination before treatment showed ova of *Ascaris* and *Trichuris*. Blood examination before treatment: 4,220,000 erythrocytes; 80 per cent hæmoglobin. Blood examination 3 months 20 days after treatment: 4,750,000 erythrocytes; 95 per cent hæmoglobin. Weight advanced 2.2 kilograms. No worms were recovered on screening the stools after treatment. He received 8.7 cubic centimeters of carbon tetrachloride.

Prisoner 19189.—Aged 38 years. Laborer. Tubercular involvement of lungs. Microscopic examination before treatment showed ova of *Trichuris*. Blood examination before treatment: 4,950,000 erythrocytes; 65 per cent hæmoglobin. Blood examination 3 months, 16 days after treatment; 4,500,000 erythrocytes; 90 per cent hæmoglobin. Weight declined 2.2 kilograms. No worms were recovered on screening the stools after treatment. He received 6.9 cubic centimeters of carbon tetrachloride.

The following seven protocols are of subjects who were infested with hookworms:

Prisoner 14646.—Aged 18 years. Laborer. Personal history and physical examination yielded nothing of importance. Microscopic examination before treatment showed ova of hookworm and *Ascaris*. Blood examination before treatment: 5,040,000 erythrocytes; 80 per cent hæmoglobin; 18.5 per cent eosinophiles. Blood examination 3 months 16 days after treatment: 5,000,000 erythrocytes; 97 per cent hæmoglobin; 3.5 per cent eosinophiles. Weight advanced 0.9 kilogram. On screening the stools after treatment 9 *Necator* and 4 *Ascaris* were recovered. He received 7.5 cubic centimeters of carbon tetrachloride.

Prisoner 14658.—Aged 34 years. Merchant. Personal history and physical examination yielded nothing of importance. Blood examination 3 months, 10 days after treatment: 5,000,000 erythrocytes; 100 per cent hæmoglobin; eosinophiles not counted. Weight declined 5.6 kilograms. On screening the stools after treatment 1 *Ancylostoma*, 354 *Necator*, and 9

Ascaris were recovered. He received 10.4 cubic centimeters of carbon tetrachloride.

Prisoner 14764.—Aged 35 years. Laborer. Personal history and physical examination unimportant, except for a kyphosis. Blood examination before treatment: 4,300,000 erythrocytes; 78 per cent hæmoglobin; 4 per cent eosinophiles. Blood examination 3 months, 11 days after treatment: 4,950,000 erythrocytes; 95 per cent hæmoglobin; 22 per cent eosinophiles. Weight remained stationary. On screening the stools after treatment 20 *Ancylostoma*, 24 *Necator*, and 43 *Trichuris* were recovered. He received 9.1 cubic centimeters of carbon tetrachloride.

Prisoner 57340.—Aged 45 years. Laborer. Personal history unimportant. Physical examination developed that there was prolonged expiration over both sides posteriorly; impaired resonance of the right lower posteriorly. Many fine crepitant râles at the right lower. Blood examination before treatment: 3,500,000 erythrocytes; 87 per cent hæmoglobin; 11 per cent eosinophiles. Blood examination 2 months, 16 days after treatment: 4,150,000 erythrocytes; 90 per cent hæmoglobin; eosinophiles not counted. Weight advanced 2.9 kilograms. On screening the stools after treatment no adult hookworms were recovered. The fæces, however, contained numerous hookworm larvæ which presumably had hatched from ova present in the fæces before treatment, for no ova were found in his stool 2 months and 16 days after treatment.[2] He received 7.1 cubic centimeters of carbon tetrachloride.

At a second physical examination, two and one-half months after treatment, this man's lungs were clear on percussion and auscultation.

Obviously, this man was very lightly infected with hookworm. An accompanying infection with *Trichuris* likewise was very light, for it was only detected on concentration of the fæces. It seems unlikely, therefore, that his anæmia was the product of a helminthiasis, and his general improvement in health would seem to have been the result of the improvement in his mode of life that took place when he entered prison.

Prisoner 57342.—Aged 41 years. Laborer. Personal history and physical examination unimportant. He was, however, profoundly parasitized. He harbored, in addition to hookworm, *Ascaris*, *Trichuris*, *Entamœba histolytica*, and *E. coli*. Blood examination before treatment: 4,850,000 erythrocytes; 58 per cent hæmoglobin; 11 per cent eosinophiles. Blood examination 2 months, 15 days after treatment: 5,550,000 erythrocytes; 95 per cent hæmoglobin; 33 per cent eosinophiles. Weight advanced 1.8 kilograms. On screening the stools after treatment 6 *Ancylostoma* and 142 *Necator* were recovered. He received 7.6 cubic centimeters of carbon tetrachloride.

On reëxamination of the fæces of this man, two and one-half months after treatment, he was found still to be infected with

[2] This is of passing interest as indicating that hookworm ova and, possibly, sheathed larvæ are impervious to the action of carbon tetrachloride.

hookworm, *Trichuris*, and both of the amœbæ. We consider it likely that the elevation of his eosinophilia from 11 to 33 per cent was an expression of a cumulative effect, resulting from the persistence of his hookworm infection. A similar condition is presented by the next case.

Prisoner 57345.—Aged 36 years. Laborer. Personal history and physical examination not significant. Blood examination before treatment: 3,900,000 erythrocytes; 35 per cent hæmoglobin; 9.5 per cent eosinophiles. Blood examination 2 months, 15 days after treatment: 4,730,000 erythrocytes; 90 per cent hæmoglobin; 31 per cent eosinophiles. Weight advanced 4.7 kilograms. On screening the stools after treatment, 32 *Ancylostoma*, 271 *Necator*, and 1 *Trichuris* were recovered. He received 6.2 cubic centimeters of carbon tetrachloride.

Like the preceding subject, this man's fæces still contained ova of hookworm and *Trichuris* on examination, two and one-half months after treatment. His eosinophilia had increased from 9.5 per cent to 31 per cent; but, as shown above, he had increased substantially in weight.

Prisoner 14726.—Aged 30 years. Laborer. Personal history and physical examination irrelevant. Blood examination before treatment: 4,050,000 erythrocytes; 45 per cent hæmoglobin; 1.5 per cent eosinophiles. Blood examination 2 months, 3 days after treatment: 5,700,000 erythrocytes; 95 per cent hæmoglobin; 12 per cent eosinophiles. Weight declined 4.4 kilograms. On screening the stools after treatment 23 *Ancylostoma* and 77 *Necator* were recovered. He received 8.9 cubic centimeters of carbon tetrachloride.

On reëxamination of the fæces of this subject, two months after treatment, he was found still to be infested with hookworm and *Trichuris*.

For the reasons already stated, we refrain from any detailed discussion of the weights of these and the other men in the series, but as a point of general interest we present a few figures in connection with the eighty-eight men who were weighed both before and after treatment.

Weights were taken after periods ranging from 2 months, 4 days to 3 months, 21 days after treatment.

A gain in weight was recorded in fifty subjects, and a loss in thirty. Eight of the men showed no change in weight.

The maximum increase in weight, 10.4 kilograms, was recorded in a man who was infected with hookworm, *Ascaris*, and *Trichuris*. When examined before treatment, on June 22, 1922, his chest revealed crepitant râles and impaired resonance. His condition was unchanged on September 1.

The maximum loss in weight, 9.1 kilograms, was in a man who showed no evidence of tuberculosis during the time he was under our observation. He showed no abnormal reaction to the drug beyond the passage of considerable bile and mucus in his stool. This man presented a waxy, diabetic appearance. He had a soft, fixed tumor mass, about the size of a hen's egg, in the left lumbar region, about the level of the fourth lumbar vertebra.

VASCULAR SYSTEM

Pulse rate and blood pressures were taken before treatment, at the time the physical examination was made, and again one hour after the administration of the drug while the men still were partially under its effects. Nothing of especial significance was noted by us, but we feel that a careful study of the cardiovascular system during treatment with carbon tetrachloride is needed to make the picture complete. This of course should be made with care, to avoid the fallacies that creep into such work when it is undertaken under routine conditions.

No subjects were encountered in the series who gave any evidence of serious cardiac lesion. Physical examination, however, disclosed four with minor affections of the heart. These were prisoners 14643, who showed a soft systolic murmur, best heard over the mitral region; 57342, with a roughened first sound which was absent three months after treatment; 14710, with an occasional reduplication of the second sound, which likewise had disappeared three months later; and, 19369, with a short mitral systolic murmur, best heard over the second interspace left transmitted toward the left axilla.

APPEARANCE OF WORMS IN STOOLS AFTER TREATMENT

One of the most striking things noted in connection with the treatment was the promptness with which the hookworms were eliminated after treatment. Inspection of the figures at the conclusion of the work disclosed that 97 per cent of the hookworms recovered on screening were passed within the first twenty-four hours after treatment. This, however, was not the case with either *Ascaris* or *Trichuris*. Only 54 per cent of the total number of *Ascaris* recovered were found in the first twenty-four hours, and only 19 per cent of *Trichuris* recovered came down in that time. The greater number of *Trichuris* was expelled on the second day.

To determine how soon worm findings could be made after treatment, six men were treated on the basis of 1 cubic centimeter

of carbon tetrachloride to each 6 kilograms of body weight. The men were watched, and the first stool passed by each was sent to the laboratory for screening. The drug was administered at 1.40 o'clock in the afternoon. Every man in the group had defecated before 2.45 o'clock. The results are shown in Table 16. It will be seen that 17 per cent of the hookworms were eliminated in the first stool.

TABLE 16.—*Stool findings in six cases one hour after treatment.*

Prisoner No.—	Worms recovered.		
	First stool.	Add first day.	Second day.
14674	None	44 hookworms; 10 *Trichuris*	0
14675	17 hookworms; 1 *Ascaris*	13 hookworms; 1 *Trichuris*	0
14676	3 hookworms	19 hookworms; 2 *Trichuris*	53 *Trichuris*.
14677	13 hookworms; 1 *Ascaris*; 2 *Oxyuris*.	76 hookworms; 90 *Oxyuris*	0
14678	2 *Ascaris*; 1 *Oxyuris*	1 hookworm; 4 *Ascaris*	0
14679	2 *Oxyuris*	2 hookworms; 1 *Ascaris*; 9 *Oxyuris*.	0

The findings on screening the stools of the hookworm-positive cases are shown in Table 17. These are recorded day by day, together with the amount of drug administered. It will be seen that there appears to be no correlation whatever between the quantity of carbon tetrachloride administered and the proportionate number of worms recovered on the first day.

Of the total number of worms passed by these men in the stools collected during the three days succeeding treatment, 97 per cent were contained in the stools passed during the first twenty-four hours. In fact, 63 per cent of the men seemed to have unburdened themselves of their total stock of worms in this time, for none were found on the subsequent days. In only two instances did we recover worms from stools passed on the third day. The stools of seven men were negative throughout. It has been noted that the lightly infected cases seem to be the more difficult to clear. It is highly probable that these cases were lightly infected and that the worms were passed either in a condition of extreme maceration, or were lost in particularly bulky stools, of which there were many. Prisoners are fed unpolished rice at Bilibid, and the stools are usually full of husks which add great difficulties to the search for worms.

The dosages of carbon tetrachloride administered to the subjects from whom we failed to recover hookworms on screening ranged from 6.6 to 11.2 cubic centimeters.

TABLE 17.—*Number of hookworms recovered each day after treatment.*

Prisoner No.—	Carbon tetrachloride given.	Worms recovered.		
		First day.	Second day.	Third day.
	cc.			
14707	9.5	78	0	0
14708	11.3	91	0	0
14709	10.3	5	0	0
14710 [a]	11.2	0	0	0
14711	8.3	4	0	0
14712	9.3	26	0	0
14713	10.0	25	0	0
14714	9.0	2	0	0
14715	10.8	21	0	0
14717	10.0	16	0	0
14718	12.0	43	0	0
14719	9.4	9	0	0
14721	11.1	7	0	0
14722	10.8	2	0	0
14723	9.4	9	0	0
14724	9.4	7	0	0
14725	10.8	29	1	0
14726	8.9	99	1	0
14727	10.8	74	3	0
14728	9.2	24	0	0
14729	9.2	46	0	0
14730	9.2	22	0	0
14731	8.7	37	0	0
14733	11.6	10	0	0
19366	11.7	96	1	0
19367	9.3	14	1	0
19369	9.8	2	10	0
19370	8.7	3	9	0
14966	8.7	24	0	0
14969	12.5	24	0	0
15001	10.4	14	0	0
58762	10.0	90	8	0
14641	8.9	68	1	0
14642	10.8	107	11	0
14646	7.5	9	0	0
19180	10.8	7	1	0
19188	7.3	12	0	0
57127	11.4	22	1	0
57129 [a]	9.4	0	0	0
57140	7.1	10	2	0
14654	9.9	23	0	0
14656	8.3	0	2	0
14657	10.0	4	27	0
14658	10.4	356	0	0
14659	8.6	244	0	0
14660	10.0	38	2	0
14661	9.9	23	0	0
14662	8.0	70	0	0

[a] No worms were recovered on screening the stools.

TABLE 17.—*Number of hookworms recovered each day after treatment*—Continued.

Prisoner No.—	Carbon tetrachloride given.	Worms recovered.		
		First day.	Second day.	Third day.
	cc.			
14663	8.9	10	0	0
14664	8.9	4	0	0
14666 [a]	6.6	0	0	0
14667	9.0	9	0	0
14668	8.3	73	0	0
14669	9.3	6	0	0
14670	8.5	24	0	0
14671	9.8	8	0	0
14672	8.5	7	0	0
14673	9.1	19	0	0
14674	9.1	44	0	0
14675	12.5	13	0	0
14676	8.9	19	0	0
14677	8.3	76	0	0
14678	11.9	1	0	0
14679	8.7	2	0	0
14680	8.4	154	0	0
14681 [a]	9.0	0	0	0
14682	6.6	1	1	0
14683	8.3	3	0	0
14684 [a]	6.6	0	0	0
14685	9.4	11	0	0
14686	7.5	27	0	0
14687	9.4	2	0	0
14689	7.6	70	2	1
14690	8.7	14	2	0
14691	9.0	17	0	0
14692	6.2	16	0	0
14693	7.1	9	0	0
14694 [a]	7.5	0	0	0
14695	6.2	2	0	0
14702	8.1	121	0	0
14703	8.2	22	0	0
14704	7.6	13	0	0
14705	7.8	149	0	0
57340 [a]	7.1	0	0	0
57341	8.3	98	0	0
57342	7.6	148	0	0
57343	7.1	56	0	0
57345	6.2	301	1	1
57346	7.8	1	0	0

[a] No worms were recovered on screening the stools.

The foregoing data shed no definite light as to whether *Ancylostoma duodenale* is or is not more resistant to the action of carbon tetrachloride than is *Necator americanus*. The fact re-

mains, however, that only 30 per cent of the worms expelled after the first day were *Ancylostoma*. In our judgment, it is not likely that any difference in response would be noticeable in the doses we administered, which are proportionately larger than those given by other investigators. Whether or not the high efficiency of the drug which led to the expulsion of 97 per cent of the total number of worms within the first twenty-four hours can be turned to account in the saving of time and labor in future surveys remains to be determined.

Carbon tetrachloride, as has been said, is not nearly so efficient a vermicide against *Ascaris* and *Trichuris* as it is against hookworm. Based on stool examination, not of itself entirely conclusive, we succeeded in clearing only five *Ascaris* and three *Trichuris* infestations. At the same time, we regard our results in the treatment of *Trichuris* infestation as somewhat encouraging, for it will be seen on scanning Table 19 that in several instances the drug brought about the expulsion of numerous worms, even though ova were found at a subsequent microscopical examination. In the treatment of subjects infested with *Ascaris* and *Trichuris*, we failed to recover *Ascaris* in eleven cases and *Trichuris* in sixty-three. In six instances we recovered *Ascaris* on screening the stools, only to find the ova on reëxamination. We likewise recovered *Trichuris* in eighteen cases, the ova being recovered on reëxamination.

This performance seemed to bear no relation whatever to the quantity of drug administered, as will be seen by inspection of Table 18, which sets forth the doses administered to eleven *Ascaris*-infected subjects from whom no adult worms were recovered after treatment.

TABLE 18.—*Quantity of carbon tetrachloride administered to eleven subjects infested with Ascaris, from whom no Ascaris were recovered.*

Prisoner No.—	Quantity of drug. cc.
19366	11.7
14709	10.3
14722	10.8
14724	9.4
14726	8.9
14731	8.7
14682	6.6
14704	7.6
57342	7.6
13112	8.7
14641	8.9

When the drug acts at all, it seems to act effectively, for nearly all the worms recovered within the first few hours after treatment were dead, the few that were recovered alive being moribund. This may in itself be a danger as leading to the retention of dead worms the presence of which in the intestinal tract may give rise to unpleasant symptoms, as is pointed out by Haughwout and Ash.(5)

The location of *Trichuris* in the large intestine is unfavorable as regards the application of the drug. The drug reaches the lower intestine in a state of dilution and at a time when peristalsis has been stimulated to a marked degree. The consequence is that it has little time to exert itself on the worms, but is hurried past them in a weakened concentration. The surprising thing is that it is as efficient as our figures show it to be in certain cases. We are led to suspect, though we have no definite data to support the supposition, that the cases in which it seemed to act most efficiently were afforded by patients whose bowels did not move so briskly or so promptly as did those of the other men. The observations on the cases of *Ascaris* and *Trichuris* infestation are recorded in Table 19.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations.*

Case No.—	Dose.	*Ascaris.*			*Trichuris.*			Final stool examination.
		First day.	Second day.	Third day.	First day.	Second day.	Third day.	
	cc.							
19366	11.7	0	0	0	0	0	0	Not done.
19367	9.3	2	1	0	0	0	0	Do.
19369 [a]	9.8	------	------	------	0	0	0	Do.
19370 [a]	8.7	------	------	------	0	0	0	Do.
14966	8.7	2	0	0	0	3	0	Do.
14969 [b]	12.5	1	0	0	------	------	------	Do.
15001 [b]	10.4	0	3	0	------	------	------	Do.
58762 [b]	10.0	3	1	0	------	------	------	Do.
14707 [a]	9.5	------	------	------	0	0	0	Negative.
14708 [a]	11.3	------	------	------	0	0	0	*Trichuris* +.
14709	10.3	0	0	0	0	0	0	Do.
14710	11.2	0	0	0	3	0	0	Do.
14711	8.3	4	0	0	0	0	0	Do.
14712	9.3	3	0	0	0	0	0	Do.
14713 [a]	10.0	------	------	------	0	0	0	Do.
14714 [a]	9.0	------	------	------	0	0	0	Negative.
14715	10.8	8	0	0	0	0	0	*Trichuris* +.
14717 [a]	10.0	------	------	------	0	0	0	Negative.
14718 [a]	12.0	------	------	------	0	1	0	*Trichuris* +.
14719	9.4	1	0	0	1	0	0	Do.

[a] Not infested with *Ascaris*. [b] Not infested with *Trichuris*.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations*—Continued.

Case No.—	Dose.	*Ascaris.*			*Trichuris.*			Final stool examination.
		First day.	Second day.	Third day.	First day.	Second day.	Third day.	
	cc.							
14721	11.1	1	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
14722	10.8	0	0	0	0	0	0	*Trichuris* +.
14723	9.4	1	23	0	7	27	0	Negative.
14724	9.4	0	0	0	18	1	0	*Trichuris* +.
14725	10.8	3	0	0	0	0	0	Do.
14726	8.9	0	0	0	0	0	0	Do.
14727	10.8	3	1	0	0	0	0	Do.
14728	9.2	13	4	0	0	0	0	Do.
14729	9.2	4	0	0	3	0	0	Negative.
14730	9.2	2	0	0	0	0	0	*Trichuris* +.
14731	8.7	0	0	0	0	0	0	Do.
14733	11.6	6	1	0	0	0	0	Do.
14680	8.4	0	1	0	0	0	0	Do.
14681	9.0	0	1	0	0	0	0	Do.
14682	6.6	0	0	0	0	0	0	Do.
14683 [c]	8.3	0	3	0	0	0	0	Do.
14684 [c]	6.6	0	3	0	0	0	0	Do.
14685 [a]	9.4	------	------	------	0	0	0	Negative.
14686 [a]	7.5	------	------	------	1	40	0	*Trichuris* +.
14687	9.4	------	------	------	0	2	0	Do.
14689 [c]	7.6	------	[d] 1	------	0	0	0	Negative.
14691 [c]	9.0	1	0	0	0	4	0	Do.
14692 [b]	6.2	4	7	0	------	------	------	*Ascaris* +.
14693	7.1	1	0	0	0	0	0	*Trichuris* +.
14694 [a]	7.5	------	------	------	0	0	0	Do.
14695 [c]	6.2	2	0	0	0	0	0	Do.
14702	8.1	4	0	0	0	0	0	Do.
14703 [a]	8.2	------	------	------	0	0	0	Negative.
14704	7.6	0	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
14705	7.8	2	1	1	0	0	0	*Trichuris* +.
57340 [a]	7.1	------	------	------	0	0	0	Do.
57342	7.6	0	0	0	0	0	0	Do.
57343	7.1	2	0	0	0	0	0	Not done.
57345 [a]	6.2	------	------	------	0	0	1	*Trichuris* +.
57346	7.8	7	0	1	0	0	0	Do.
14654 [a]	9.9	------	------	------	0	1	0	Do.
14656 [a]	8.3	------	------	------	0	0	0	Do.
14657	10.0	6	1	0	0	0	0	Do.
14658	10.4	9	0	8	0	0	1	Do.
14659	8.6	2	2	0	0	0	0	Do.
14660	10.0	7	0	0	0	1	0	Do.

[a] Not infested with *Ascaris*.
[b] Not infested with *Trichuris*.
[c] *Ascaris* ova not found on first examination.
[d] Immature worm.
[e] *Trichuris* ova not found on first examination.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations*—Continued.

Case No.—	Dose.	*Ascaris.*			*Trichuris.*			Final stool examination.
		First day.	Second day.	Third day.	First day.	Second day.	Third day.	
	cc.							
14661 [c]	9.9	0	1	0	0	0	0	*Trichuris* +.
14664 [a]	8.9				0	0	0	Do.
14666 [a]	8.6				0	0	0	Do.
14669 [a]	9.0				0	0	0	Do.
14668 [a]	8.3				1	7	1	Negative.
14669	9.3	4	0	0	1	2	0	*Trichuris* +.
14670	8.5	10	0	0	0	0	0	Do.
14671	9.8	7	0	0	2	2	1	*Ascaris* +, *Trichuris* +.
14672 [a]	8.5				0	1	0	*Trichuris* +.
14673	9.1	9	1	2	11	15	43	*Trichuris* +, heavy.
14674 [a]	9.1				10	33	0	*Trichuris* +.
14675 [c]	12.5	[f] 1	0	0	0	1	0	Do.
14676	8.9	0	0	0	2	53	0	*Ascaris* +, *Trichuris* +.
14678	11.9	4	0	0	0	0	0	*Trichuris* +.
11389 [a]	8.8				0	0	0	Do.
13112	8.7	0	0	0	0	0	0	Negative.
14579	8.1	0	3	0	0	0	0	Do.
14641	8.9	0	0	0	0	0	0	*Trichuris* +.
14642	10.8	24	2	0	0	0	0	Do.
14634 [c]	8.3	1	0	0	0	0	0	Do.
14646 [b]	7.5	4	0	0				Do.
19174	8.8	6	0	0	0	0	0	Do.
19180	10.8	2	0	0	0	0	0	Do.
57600	8.1	5	0	0	0	0	0	Do.
19188 [a]	7.3				0	0	0	Do.
19189 [a]	6.9				0	0	0	Do.
56471 [c]	7.7	1	0	0	0	0	0	Do.
57112	8.0	0	11	0	0	3	0	Do.
57127	11.4	3	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
57128 [a]	8.9				0	0	0	*Trichuris* +.

[a] Not infested with *Ascaris*.
[b] Not infested with *Trichuris*.
[c] *Ascaris* ova not found on first examination.
[f] Male worm.

To summarize: It will be seen by Table 19 that 54 per cent of the total number of *Ascaris* recovered after treatment were passed within the first twenty-four hours, and 75.3 per cent during the first two days. Twenty-eight men passed no *Ascaris* after the first day; eighteen, none after the second day; and only four passed *Ascaris* on the third day.

In the case of *Trichuris*, however, only 19 per cent of the total number of worms recovered were passed the first day, but the percentage had risen to 84.5 the second day. Subjects who passed no *Trichuris* after the first day numbered only three, and fifteen passed none after the second day. Five subjects yielded *Trichuris* on the third day.

This makes it clear that the drug is not devoid of efficiency against both species. The apparent delay in the reaction of the drug against *Trichuris* is interesting, and it is not unlikely that it is slightly more efficient than our figures show. It must be borne in mind that *Trichuris* implants itself much more firmly in the intestinal wall than do any of the other species of nematodes and, while many of the worms may be killed by treatment, their appearance in the fæces may be delayed until maceration progresses to the point where they break off along the course of the relatively thin "neck," at or near the point of penetration into the mucosa. It seems to us more likely that this furnishes the explanation for this phenomenon rather than a supposedly cumulative effect of the drug itself.

OCCUPATIONAL DISTRIBUTION OF WORM COUNTS

Though this phase of the hookworm problem is outside of the scope of this paper, it seems not inappropriate to record the distribution of worm counts with relation to the occupations of the several men. Summarizing the worm counts for the entire series, it is seen that 3,539 hookworms were recovered after treatment. Of this number, 2,929 were *Necator americanus* and 610 *Ancylostoma duodenale*. The men, as has been said, were drawn from widely separated portions of the Archipelago and to a certain degree may be said to be fairly representative of the Philippine Islands as a group. This yields a rather high ancylostoma index, 17.2, thus fulfilling the prediction of Haughwout(4) that *Necator americanus* probably would be shown to be the dominant species in the Philippines, but that the ancylostome index might be fairly high.

By far the greater number of our subjects were registered on the prison records as laborers, but there is reason to doubt that the records regarding occupation as given to the prison authorities were in all instances correct. For instance, we found that a chief of police from Cebu Province harbored 154 worms, while a "merchant" from Sorsogon yielded 355. We are inclined to believe that the chief of police either did not wear his full equipment at all times or that he was engaged in some

agricultural occupation on the side. We also doubt if our "merchant" spent a great deal of time in his counting house. However, we think that the allotment of seventy-two men to the class of laborers is substantially correct. Sixty-seven of these men were infested with hookworms.

On screening the stools of these men, we recovered 2,546 hookworms, of which 2,070 were *Necator americanus* and 476 *Ancylostoma duodenale*. Only 2 pure *Ancylostoma* infestations were found, while there were 20 pure *Necator* infestations. We failed to recover worms from the stools of six men.

The worm counts in the various groups are presented in Tables 20, 21, and 22. They are correlated with the age and place of residence of each man. We believe it would be unprofitable at this time to discuss the occupational incidence in this series, for proper interpretation of the figures presupposes fuller information regarding local soil and meteorologic conditions than is yet in our possession. Certain anomalies in our tables will be quite apparent to those familiar with the occupational phases of hookworm survey work.

TABLE 20.—*Hookworm counts on laborers in relation to age and provincial residence.*

Prisoner No.—	Age.	Province.	*Ancylostoma.*	*Necator.*	Total.
	Years.				
14708	33	Albay	0	91	91
14686	52	Antique	14	12	26
14687	58	do	0	2	2
14661	48	Batangas	0	18	18
14662	31	do	2	68	70
14663	26	do	0	10	10
14664	26	do	0	4	4
57127	26	Bohol	1	22	23
14725	45	Cagayan	8	22	30
14726	30	do	23	77	100
14727	27	do	27	40	67
14728	19	do	5	19	24
14730	32	do	2	20	22
14731	27	do	16	21	37
14733	43	do	6	4	10
14677	23	Cebu	19	57	76
14678	32	do	0	1	1
14679	26	do	0	2	2
14681	24	do	0	0	0
14689	37	Ilocos Norte	10	62	72
14690	32	do	2	14	16
14691	37	do	5	12	17
14692	38	do	3	13	16
14729	20	do	9	37	46

TABLE 20.—*Hookworm counts on laborers in relation to age and provincial residence*—Continued.

Prisoner No.—	Age.	Province.	*Ancylostoma.*	*Necator.*	Total.
	Years.				
14682	42	Ilocos Sur	0	2	2
14683	32	do	3	0	3
14693	48	Isabela	0	9	9
14694	30	do	0	0	0
14695	38	do	0	2	2
14685	29	Laguna	0	11	11
14702	56	Leyte	11	110	121
14703	45	do	6	16	22
14704	23	do	1	12	13
14705	17	do	12	137	149
57340	45	do	0	0	0
57341	19	do	36	62	98
57342	41	do	6	142	148
57343	23	do	19	37	56
57345	36	do	32	271	303
57346	23	do	0	1	1
14646	18	Manila	0	9	9
57140	17	do	0	12	12
14642	26	Misamis	32	86	118
14684	36	Mountain	0	0	0
14668	25	Occidental Negros	39	34	73
14670	17	do	4	20	24
14671	25	do	2	6	8
14672	40	do	0	7	7
14673	42	do	1	18	19
14674	35	do	20	24	44
14675	64	do	0	13	13
14676	38	do	10	9	19
14966	32	do	14	10	24
58762	20	do	17	81	98
14969	31	Nueva Ecija	15	9	24
14717	26	do	6	10	16
14666	30	Palawan	0	0	0
14667	19	do	0	9	9
14709	21	Pampanga	5	0	5
19180	22	Panay	2	6	8
14710	45	Pangasinan	0	0	0
14711	25	do	2	2	4
14713	38	do	9	16	25
14714	25	do	0	2	2
14715	53	do	20	1	21
14722	37	Samar	0	2	2
14659	37	Sorsogon	0	244	244

SUMMARY

Our study of the action of carbon tetrachloride in various dosages, on a group of one hundred male Filipinos in Bilibid Prison, has led to findings that we regard as fairly definite. These

TABLE 21.—*Hookworm counts in relation to occupation, age, and provincial residence.*

Prisoner No.—	Age.	Province.	Occupation.	*Ancylostoma.*	*Necator.*	Total.
14641	28	Cavite	Farmer	4	65	69
19369	26	Nueva Ecija	do	7	26	33
19366	59	Pangasinan	do	49	38	87
19367	35	do	do	14	1	15
19370	70	do	do	5	7	12
14719	19	Tayabas	Carpenter	1	8	9
57129	31	Misamis	do	0	0	0
14660	22	Sorsogon	Employee	0	38	38
14721	37	Samar	do	0	7	7
14664	25	Cuyo	Barber	0	4	4
14707	29	Albay	do	0	78	78
14669	21	Jolo	Foreman	1	5	6
14680	28	Cebu	Chief of police	8	146	154
14712	33	Pangasinan	Mechanic	0	26	26
14718	23	Tayabas	Lavandero	11	32	43
14654	47	Laguna	Proprietor	1	22	23
14656	31	Sorsogon	Soldier	0	2	2
14657	20	do	Messenger	4	27	31
14658	34	do	Merchant	1	354	355
14723	37	Cagayan	Clerk	7	2	9
14724	33	do	Sailor	3	4	7
15001	?	(?)	Unknown	10	4	14
19188	26	Rizal	Agent	10	2	12

TABLE 22.—*Distribution of subjects according to occupation.*

Occupation.	Total.	Infected with hookworm.
Laborer	72	67
Farmer	5	5
Student	1	1
Lavandero	1	1
Clerk	1	1
Foreman	1	1
Treasurer	1	0
Employee	2	2
Proprietor	2	1
Barber	2	2
Agent	1	1
Mechanic	1	1
Stenographer	1	0
Boxer	1	0
Carpenter	2	2
Soldier	1	1
Sailor	1	1
Messenger	1	1
Merchant	1	1
Chief of police	1	1
Unknown	1	1

findings have been conclusively checked and confirmed, so far as concerns the dosage, by the treatment of more than 25,000 Filipinos of all ages and both sexes as well as in varying conditions of disease and health, by the heaviest dosages we have employed in this series.

Not only have there been no fatalities, but in no instance has a subject shown a physical reaction to the drug that has necessitated treatment or has given the slightest cause for anxiety on the part of those who administered it.

We attribute our immunity from such mishaps to the observance of three fundamental principles.

1. The administration of a drug of known purity as attested by chemical examination and purification. In no instance have we accepted the word of the manufacturer with respect to the purity of the drug.

2. The rejection of all persons showing obvious pathology of the liver,[3] and serious lesion of the heart or urinary system.

3. The rejection of all acute alcoholic subjects, and the withdrawal of alcohol for a period of days prior to treatment from all subjects who indulged in it to even a moderate degree.

Our maximum dosages were computed on the basis of data obtained by the administration of maximum doses to three condemned murderers, and finally checked by the anatomical and histological examinations of the organs of a man who was executed three days after taking a maximum dose. We failed to find any evidence of drug intoxication in this case.

Observations made before, during, and after the treatment of these one hundred men has yielded us information that we summarize as follows:

BLOOD AND VASCULAR SYSTEM

Blood.—Few significant data were obtained by study of the blood. Many cases showed a polycythæmia and high hæmoglobin percentage before treatment. No changes were noted in these that could be attributed to the direct action of the drug. In many cases there was a tendency toward a transient elevation in the proportionate number of polymorphonuclear neutrophiles. The behavior of the eosinophiles was erratic, and no general conclusions can be drawn.

Vascular system.—Our studies on the pulse and blood pressure yielded us no information on which we care to base conclusions.

[3] It will be recalled that we treated one man who was jaundiced without, however, observing any untoward effects.

This is a phase of the action of the drug that should be given further study.

Heart.—No untoward cardiac symptoms were noted during treatment, even in cases showing slight cardiac irregularities.

RESPIRATORY AND NERVOUS SYSTEMS

Nothing was observed that could be attributed to the direct action of the drug.

URINARY SYSTEM

Beyond the transient appearance of casts after treatment we secured no evidence of irritant action of the drug on the kidneys; this notwithstanding we administered it to subjects showing a mild degree of renal disturbance.

DIGESTIVE SYSTEM

Our observations yielded us abundant evidence that carbon tetrachloride exerts a stimulative action upon the liver. We observed nothing, however, that led us to suspect that this effect is more than transient under the doses administered by us. This effect was made evident through a hypersecretion of bile in the stools in many instances and, in one instance, possibly, by the discovery of bile in the urine of a subject twenty-four hours after treatment. In no instance was complaint made of pain or tenderness referred to the liver.

The drug also has an irritant effect on the intestinal tract; although few subjects complained of distress. This is expressed by the production, in some cases, of rather excessive quantities of mucus, sometimes accompanied by abdominal pain. The relations of these phenomena to the quantity of drug taken are not very constant. The hypersecretion of both bile and mucus may persist for two or three days, but usually it subsides within twenty-four hours after the administration of the drug.

On the basis of the foregoing and other observations we have made, we are led to conclude the following:

CONCLUSIONS

The same care should be exercised in prescribing carbon tetrachloride as is observed in the administration of any potent drug that may work harm in the presence of contraindications or in excessive quantities. In other words, *it always should be given under competent medical supervision.*

Doses of *pure* carbon tetrachloride, computed on the basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight, are safe in the absence of the contraindications we have

mentioned. On this basis, we have administered doses ranging up to 12.5, and even 15 cubic centimeters, without observing untoward effects of a serious nature.

We do not, however, maintain that this should be the standard dose. Our studies have yielded us abundant evidence that smaller proportions are equally efficient in the removal of hookworms and a certain proportion of other intestinal helminths.

Existing infection with *Entamœba histolytica*, provided there is no active dysenteric process, or previous infectious disease of the intestinal tract is not a contraindication provided no active process is present.

Several men showing definite pathology of one kind or another were treated on the same basis as the other men. Their defects included tuberculosis; splenic and liver enlargement, probably of malarial origin; slight renal disturbance; and valvular heart lesions. There was a total lack of significance in the reactions to the drug shown by these men. Their behavior as a group, and individually, in no way differed from that of the group of men in whom we found no physical defects.

Moderate alcoholism is not a contraindication to the administration of carbon tetrachloride, provided liquor is withheld from the men two or three days before and after treatment. Untoward effects in alcoholic subjects usually can be attributed to disregard of this rule. Statistically, the men in this series who admitted the use of alcohol showed less abnormal reaction to the drug than did those who denied the use of alcohol.

Saline purgatives should not be given immediately before treatment, for they apparently reënforce the irritative properties of the drug on the intestinal mucosa.

We consider that the administration of the drug in divided doses is both unnecessary and undesirable.

Carbon tetrachloride is without effect upon any of the common intestinal protozoa. Its administration in protozoal infections of the intestinal tract, therefore, is irrational.

Although observations have not been made on this in the work recorded here, we consider it opportune to voice our opinion that the drug should not be given during the course of any infectious disease where the heart and liver are already overburdened by a toxæmia. This applies with particular force to acute intestinal affections, and to infectious abdominal (surgical) conditions such as peritonitis. Cases may arise where it is desirable to rid a surgical patient of a hookworm infestation. In such cases, the circumstances should be made the subject of

very careful inquiry. In our opinion, the drug should be administered several days before the administration of an anæsthetic, in order that the liver may entirely recover from the stimulating effects of the carbon tetrachloride. This we deem especially important if it is desired to administer chloroform.

Among the subjects for future investigation that are suggested by our work we may mention the following: Is the administration of the drug to persons about to undergo surgical operation fraught with any dangers? Are untoward hepatic symptoms likely to arise when an anæsthetic is later administered? Would there be a tendency toward the development of ileus? Do any racial idiosyncracies to the drug exist? How is the drug eliminated? What are the effects of the drug on the cardio-vascular system? Definitely, what is the action of this drug on *Trichuris?*

Lastly, further pathologic work should be done with especial attention to the kidneys and liver. Such studies should be made with strict attention to the prevalence of mild to subacute conditions commonly found in the kidneys and livers of natives of tropical countries, which not improbably bear a more or less definite relation to the prevailing intestinal pathology in these people. Lesions of the liver should be studied with an eye to the topographic relations of the microscopic lesions.

REFERENCES

1. Chamberlain, Weston P. The influence of tropical residence on the blood. Am. Journ. Trop. Dis. & Prov. Med. 2 (1914) 41–54.
2. Docherty, J. F., and Burgess, E. The action of carbon tetrachloride on the liver. Brit. Med. Journ. No. 3228 (1922) 907–908.
3. Guerrero, Luis, and Sevilla, Victor. Examinations of the blood with special reference to malaria in the town of Taytay. Philip. Journ. Sci. § B 4 (1909) 273.
4. Haughwout, Frank G. Some less familiar aspects of parasitology. Journ. P. I. Med. Assoc. 1 (1921) 93–99.
5. Haughwout, Frank G., and Ash, J. Earle. A study of intestinal parasitism in American and European children in the Philippine Islands. (In preparation.)
6. Lambert, S. M. Carbon tetrachloride in the treatment of hookworm disease. Observations in twenty thousand cases. Journ. Am. Med. Assoc. 79 (1922) 2055–2057.
7. Leach, C. N. Carbon tetrachloride in the treatment of hookworm disease. Journ. Am. Med. Assoc. 78 (1922) 1789–1790.
8. Leach, Charles N.; Schwartz, Benjamin; and Leach, Florence Dixon; with the coöperation of Haughwout, Frank G. Hookworm disease: A clinical entity in the Philippine Islands. Philip. Journ. Sci. 23 (1923) 105.
9. Smillie, W. G., and Pessoa, S. Treatment of hookworm disease with carbon tetrachloride. Bull. International Health Bd. 3 (1922) 11.

ILLUSTRATION

PLATE 1

FIG. 1. Portal area.
2. Hepatic-vein area.

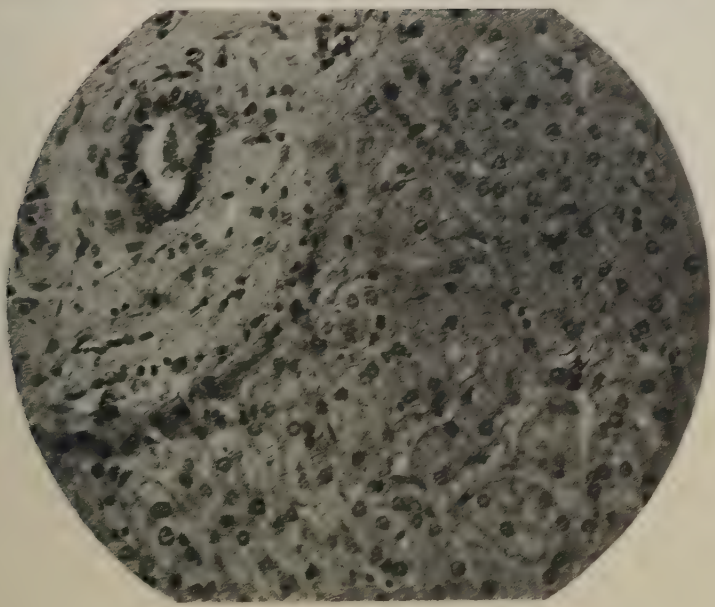

Fig. 1. Porta. area.

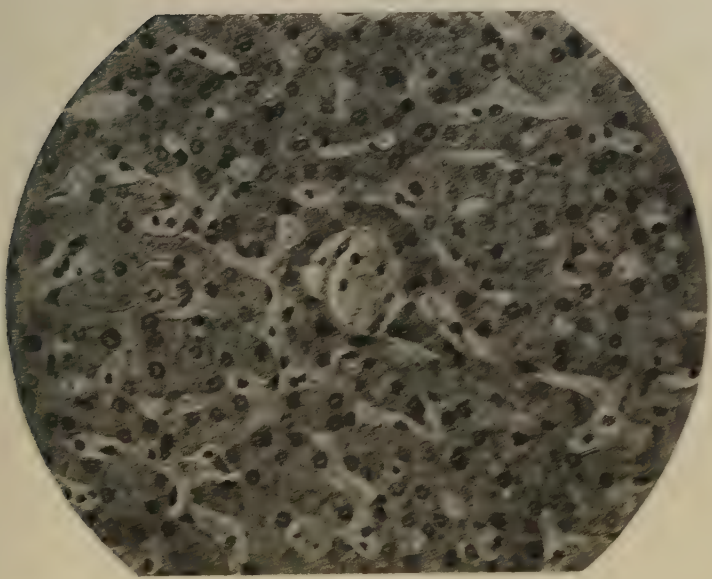

Fig. 2. Hepatic-vein area.

PLATE 1.

PRELIMINARY REPORT ON CREOSOTE AS AN ADJUVANT IN LEPROSY TREATMENT [1]

By Jose G. Samson and Gabino Limkako

Of the Medical Section, Culion Leper Colony, Philippine Health Service

TWO TEXT FIGURES

INTRODUCTION

Points of similarity or resemblance between tuberculosis and leprosy make it seem reasonable that any feature of treatment useful in the former disease may prove of value in the latter. However, it is obvious that this would not necessarily be the case, though Muir [2] was led to express the converse opinion that the effective antileprosy treatments are among the best for tuberculosis. Therefore, before applying on a large scale to leprosy treatment any drug accepted as useful in tuberculosis, its value in the former disease should be established or at least clearly indicated.

Muir, after using Rogers's sodium gynocardate and sodium morrhuate in treating lepers, introduced a mixture of chaulmoogra ethyl ester, 1 milliliter; creosote, 1 milliliter; camphor, 1 gram; and olive oil, 2.5 milliliters, which he refers to as E. C. C. O. At the time the chaulmoogra ethyl esters were being tried in the Philippines in comparison with Rogers's and other preparations, as a result of which they were adopted as the best drug for routine treatment under existing conditions. At the same time (1921), the workers then at Culion tried, in a few cases of leprosy complicated with tuberculosis, a cod-liver oil modification of Muir's formula known here as M. C. C. O., with benefit, it seemed, to patients showing the primary infection. As it was a matter of considerable interest to determine definitely whether the addition of creosote to the routine ethyl ester preparation would give better results in treatment, we had become sufficiently interested in the matter to encourage us to carry

[1] Read before the Culion Medical Society, June 29, 1923. Published with the consent of the Director of Health and the approval of the Philippine Leprosy Research Board.

[2] Muir, E., Handbook on Leprosy. Cuttack, R. J. Grundy (1921) 63.

out a series of observations with this end in mind. The work done and the results obtained are set forth here.

TREATMENT GROUPS

For our purpose one hundred ninety-four patients of both sexes and of varying ages were selected. All had been treated for nearly a year, in different groups, all receiving for the last few months the plain (noniodized) chaulmoogra ethyl esters, and from all appearances they had improved to a greater or less extent as a result of the treatment.

The patients were divided into four main groups, an attempt being made to make these uniform so far as sex and age were concerned. The type and the duration of the disease and the extent of involvement of the tissues differed so widely that it was not considered advantageous to attempt to determine the groups on this basis. The cases were practically all of the cutaneous and mixed types, and moderately advanced, though on the average not to the point of being distinctly unfavorable for treatment. Each of us treated approximately one-half of each group, more or less independently.

The observation, at the time the data herein presented were obtained, had extended over a period of six months. Injections were given intramuscularly twice a week, except when for some reason or other injection was postponed.

The treatments used were as shown in Table 1.

TABLE 1.—*Treatments used.*

Group	Cases.	Treatment.
I	53	Chaulmoogra ethyl ester, intramuscularly.
II	49	C. E. E. intramuscularly, creosote by mouth.
III	43	C. E. E., creosote, and camphor mixture.
IV	49	C. E. E. and creosote mixture.

Group I, in which there was no change from the treatment previously given to all, served as the control. Group II was treated identically except that a pill containing 0.3 milliliter of creosote was given at each injection, totaling 0.6 milliliter of this drug per week when the patient took both treatments. The dose was made small in the desire to avoid gastric irritation. Group III was given injections of a solution with the formula chaulmoogra ethyl esters, 1,000 milliliters; creosote, 25 milliliters; camphor, 25 grams. The solution given Group IV differed from this in that no camphor was used and, after the first few injec-

tions, but 12.5 milliliters of creosote to 100 milliliters of the ethyl esters. The ordinary United States Pharmacopœia grade of creosote was used almost entirely on account of the cost of the beechwood variety.

DOSAGE

As all of the patients were accustomed to receiving injections of the plain ethyl esters, the dosage that it was found possible to give the different groups is a fair indicator of the irritation, local or distant, produced by each particular preparation.

In establishing the maximum tolerated dose the drug was pushed, being increased by 1 milliliter at a step to the point of production of untoward effects, either local or general; the next lower milliliter was taken as the amount tolerated by that patient. We have observed that on attempting subsequently to increase the dose beyond this point unfavorable effects were usually produced.

TABLE 2.—*Maximum tolerated dose of creosote.*

Group.	Cases.	Percentage receiving—				
		1 cc.	2 cc.	3 cc.	4 cc.	5 cc.
I	53	1.9	0	17.0	79.2	1.9
II	49	2.0	2.0	28.6	61.2	6.1
III	43	0	9.3	72.1	14.0	4.6
IV	49	2.0	4.1	63.3	30.6	0

The data given in Table 2 are plotted in fig. 1.

The similarity of the curves of Groups I and II, which received injections of plain esters, is striking, as is that of the curves of Groups III and IV, which received creosote-ester solutions. The difference between these two pairs of curves is of interest. From the dosage figures of Table 2 the following averages are obtained: Groups I and II, 3.8 and 3.7 milliliters, respectively; Groups III and IV, 3.1 and 3.2 milliliters.

Naturally, creosote taken by mouth in small doses (Group II) does not influence the total amount of the ethyl esters that can be given intramuscularly. On the other hand, it is apparent that the incorporation of creosote in the ethyl esters, at least in the concentrations used, does lessen the amount of the mixture that can be given without undesirable effects.

It is of interest that Group III could be given practically as large doses of the creosote-camphor solution (20 per cent of each) as could Group IV with approximately 11 per cent creo-

sote and no camphor. At the outset 20 per cent creosote without camphor was used in Group IV, but this was so irritating that the amount added to the 100 milliliters of ethyl esters was reduced to 10 cubic centimeters. The patients complained of pain during injection, and serious local inflammations developed subsequently. Therefore, it is clear that camphor in this combination does reduce irritation.

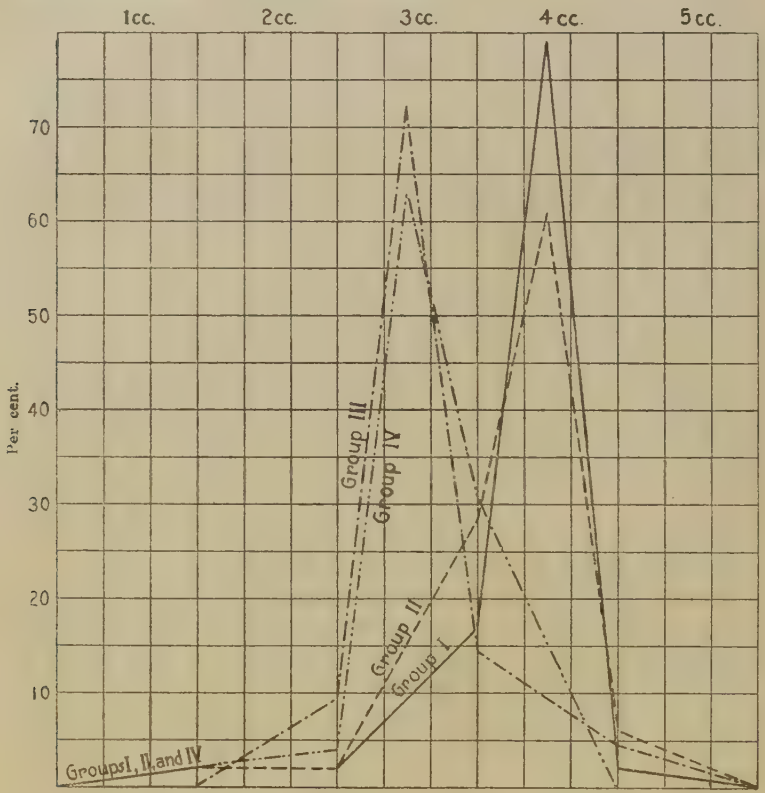

FIG. 1. The maximum tolerated dose of creosote in leprosy patients.

The matter of dosage is distinctly affected by the personal equation of the physician. For example, one of us reached a maximum dose of 4 milliliters in 91 per cent of his plain ethyl ester groups, the other in but 53 per cent. On the other hand, the first reached this dose in but one of his forty-seven cases receiving creosoted preparations (2.1 per cent), and the other in 49 per cent of forty-five patients.

INCIDENTAL EFFECTS DURING TREATMENT

In the course of the treatment various incidental conditions have arisen, resulting directly or indirectly from the treatment, that probably have more or less bearing on the results obtained.

LOCAL EFFECTS

The local effects of intramuscular injections of chaulmoogra ethyl esters are local inflammation and, infrequently, abscess formation at or near the site of injection. Local inflammation of moderate degree is a natural and constant reaction to this drug; however, usually it causes but little discomfort, lasts but a short time, and more or less completely subsides within a week. However, because of increase of dose, increased susceptibility or, perhaps, delayed absorption, more-severe reactions frequently occur which cause greater discomfort and last longer.

The number of such more-severe local reactions occurring in each group is shown in Table 3.

TABLE 3.—*Frequency of local reactions.*

Group.	Cases.	Injections.	Reactions.	Frequency per 100.	Cases reacting.	
					Number.	*Per cent.*
I	53	1,492	64	4.3	29	54.7
II	[a]46	1,158	68	5.9	29	63.1
III	43	1,132	75	6.6	33	76.7
IV	49	1,209	102	8.4	36	73.5

[a] The reactions occurring in three hypersusceptible cases are not included here.

In Group I, 4.3 per cent of the injections caused acute cellulitis. In the total of 1,200 injections given Group II, local reactions were caused 101 times, or 8.4 per cent. Of these 33, or 32.6 per cent of the total number, occurred in three patients. These were abnormally susceptible to the ethyl esters, for they had very frequently exhibited this phenomenon while under the previous routine treatment. Excluding these unusual cases, the reaction percentage in this group is 5.9 per cent. Why there should have been more reactions in this group than in Group I is not apparent. The highest incidence occurred in Group IV, 8.4 per cent of all injections causing inflammation; in Group III, with twice as much creosote but with camphor added, the rate was considerably less.

With the plain esters (Groups I and II), local effects are manifested by moderate pain and swelling at the site of injections with more or less induration; the general well-being of the patient is seldom if ever affected. With the creosote solutions (Groups III and IV), the effects occur not only more frequently, but also with a greater degree of severity. The inflammation is more extensive, pain is more severe, and sometimes the temperature rises to as high as 37.9° C. Thus, though the incidence rates in Groups II and III are approximately the same, the reactions in the latter group were more severe. This is the chief reason why the average doses were not as large as those of the pure ester.

Chaulmoogra ethyl ester is itself a local irritant, but combined with creosote it appears that its irritating effects are distinctly increased. Camphor, somehow or other, seems very considerably to reduce irritation. The more irritating character of the creosoted drug is not a serious drawback for the reason that the susceptibility of patients to this irritation is more marked at the beginning of treatment; it tends to disappear, gradually but entirely, in the course of treatment, so that after a time it causes induration no more frequently than does the plain drug.

Abscess formation at the site of injection is an unusual occurrence. In the series of one of us (Samson) this has been observed once in Group I, four times in two patients in Group II, twice in each, and once in Group IV. All were examined bacteriologically and found to be sterile. The other of us (Limkako) has not had any abscess in this series.

CHOKING AND COUGHING

Choking is a phenomenon not infrequently observed a few minutes after injections of chaulmoogra derivatives. It is manifested by paroxysmal cough with flushing of the face, perspiration, at times dizziness, and slight irritation of the pharyngeal walls. Just how it is produced has not been absolutely proven, though it is held to be probably due to accidental rapid introduction of the drug into the circulation. In this connection, it may be remarked that patients with choking complain of creosote taste and creosote odor of the breath. While it may not be important, the relative frequency of this incident in the different groups of our series is of interest.

In Group I it occurred three times in three patients; in Group II, four times in four patients; in Group III, twelve times in eleven patients; and in Group IV, fifteen times in eleven patients;

one of the last group had it three times. There were, therefore, seven instances with plain esters and twenty-seven with the creosoted, occurring in 0.26 and in 1.2 per cent, respectively, of the total injections, a comparative ratio of nearly 1 to 5. This relative frequency with the creosoted preparations is in spite of the fact that the average dose used has been somewhat less than that of the plain drug.

SIMPLE FEVER

An unusual effect which was observed only at the beginning of the work, in patients receiving the creosoted preparations, was a quick, temporary rise of temperature. With noncreosoted ethyl esters slight rise of temperature is often found to occur and to persist for several days after an injection; indeed, slight hyperpyrexia, of less than one degree, seems fairly common in lepers; but the patients themselves are not aware of it.

From one to four hours after injection of the creosoted preparations the patients frequently complain of a sensation of heat, dizziness, and abundant perspiration. The face is flushed and the pulse slightly accelerated, the rate varying from 85 to 100 per minute, and the temperature increased. This has almost invariably been between 37.1° and 37.5° C., seldom reaching 37.8° C. This more severe reaction, as in the case of the local reaction, was seen only in the early stages of the work. After a number of injections, usually three to five, it no longer occurred.

LOCAL REACTIONS

Workers in India believe that, to get the best results, the administration of antileprosy drugs should be pushed until some degree of lepra reaction, that is, apparent activation of one or more of the lesions, with or without fever, is produced. This reaction, the mechanism of the production of which has never been explained to the satisfaction of all students of the disease, occurs universally in both the treated and the untreated lepers. It cannot be doubted that the chaulmoogra ethyl esters often serve to excite the lepra reaction. Table 4 shows the relative frequency of lepra reactions in the four groups of our series.

From Table 4 it is seen that, on the basis of total number of injections given, there was no greater incidence of lepra reactions in the creosote groups than in the plain. In fact, Group II gave the highest per cent, 3.3, while the others were almost identical, 2.5, 2.4, and 2.5. However, in the actual number of persons reacting there is a distinctly higher rate for Groups

III and IV, 49 per cent, than for I and II, 40 and 43 per cent, respectively.

TABLE 4.—*Occurrence of lepra reactions.*

Group.	Cases.	Injections.	Reactions.		Cases reacting.	
			Number.	*Per cent.*	*Number.*	*Per cent.*
I	53	1,492	36	2.5	21	40
II	49	1,200	40	3.3	21	43
III	43	1,132	27	2.4	21	49
IV	49	1,209	30	2.5	24	49

DOSE PRODUCING REACTIONS

These reactions were produced, as is to be seen in Table 5 by considerably smaller doses of the creosoted preparations than of the plain.

TABLE 5.—*Dose causing lepra reactions.*

Group.	Cases.	Doses.				Total.
		1 cc.	2 cc.	3 cc.	4 cc.	
I	53	----------	11	15	10	36
II	49	3	7	19	11	40
III	43	6	9	10	2	27
IV	49	6	14	10	----------	30

It has been our experience that the lepra reactions produced with the creosote solutions are not severe. For present purposes the classification of reactions used in this colony in 1922 will be employed here; namely, Type 1, exacerbation of old lesions with fever; Type 2, exacerbations of old lesions without fever; Type 3, eruption of fresh lesions with fever; and Type 4, fresh lesions without fever. The data on the types occurring are given in Table 6. For purposes of further comparison they are tabulated in Table 7, on the basis of duration, as follows: Very brief, less than one week; brief, one to two weeks; moderately long, two to four weeks; prolonged, more than four weeks.

TABLE 6.—*Kinds of reactions.*

Group.	Reactions.	Type 1.		Type 2.		Type 3.		Type 4.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
I	36	4	11.0	5	14	5	14	22	65
II	40	3	7.5	4	10	7	18	26	65
III	27	------	--------	1	4	4	15	22	81
IV	30	------	--------	------	--------	6	20	24	80

TABLE 7.—*Duration of reactions.*

Group.	Reactions.	Very brief.		Brief.		Moderately brief.		Prolonged.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
I	36	16	44	14	39	2	5.5	4	11
II	40	12	30	21	52.5	4	10	3	7.5
III	27	7	26	13	48	3	11	4	15
IV	30	2	7	12	40	9	30	7	23

As regards the type of reaction, those in Groups I and II were essentially similar, with 65 per cent of Type 4; 14 and 18 per cent of Type 3, and less of the others. In Groups III and IV, Type 4 reactions predominated still more markedly, with 81 and 80 per cent, respectively. There was but one reaction of Type 2 and none of Type 1. In other words, practically no exacerbation of old lesions was produced by the creosoted esters, and but 15 and 20 per cent, respectively, had fever with the new lesions. The reactions caused by these preparations were milder than those produced by the plain preparations.

On the other hand, the duration of reaction with the plain preparations is very distinctly less than with the creosoted. However, in view of the mildness of the reactions, it is believed that this greater duration was not harmful. General statistics of the Culion work[3] indicate that, on the whole, the reactions of longer duration are harmful; the figures for improvement given below indicate that this was not the case in the present experiment.

RESULTS OF TREATMENT

The condition of the disease at the end of six months has been compared with that at the beginning of the present treatment, based on our records and the opinions of the patients and of ourselves. The findings are given in Table 8. Here all cases are classified as apparently negative, moderately improved, slightly improved, stationary, and worse.

The total improved, stationary, and worse are plotted in fig. 2.

According to these figures improvement under treatment with the creosoted preparations was distinctly greater than with the plain.

The totals (not shown in the table) were 51 per cent for the plain and 65 per cent for the creosoted. Comparing the four

[3] Personal communication from the acting chief physician; report in preparation for publication.

groups, Group I, with 43 per cent improved and 49 per cent stationary, gave by far the poorest results so far as improvement is concerned. The figures of Group II contrast interestingly, with 59 per cent improved and but 39 per cent stationary. The "worse" figure of this group, 2 per cent, is the lowest of the four.

TABLE 8.—*Progress under treatment.*

Group.	Cases.	Improved.			
		Negative.	Moderate.	Slight.	Total
I	53	2	9	12	23
II	49	0	18	11	29
III	43	1	8	16	25
IV	49	1	15	19	35

Group.	Stationary.	Worse.	Percentages.		
			Improved.	Stationary.	Worse.
I	26	4	43	49	7.5
II	19	1	59	39	2
III	12	6	58	28	14
IV	12	2	71	25	4

With the creosoted preparations, Group III gave practically the same improvement rate as Group II, but the "worse" rate, 14 per cent, was by far the highest in the series, almost twice as high as Group I, and three and a half times that of Group IV. The latter group gave the most satisfactory figures of the series; the improvement rate, 81 per cent, is higher than the next best by 12, the stationary rate is the lowest, and the worse rate, 4 per cent, is comparatively low.

These are total figures, for the groups of both of us. The individual figures, arrived at independently, correspond fairly closely.

RELATION BETWEEN AMOUNT OF CREOSOTE AND IMPROVEMENT

It has been the experience in the treatment work at Culion that, in general, the total improvement rate goes hand in hand with the amount of chaulmoogra injected. In other words, the larger the dose regularly taken the better the improvement. As regards creosote, we cannot draw any definite conclusion as to the relation between the amount administered and the improvement on the basis of the present observations. However, the

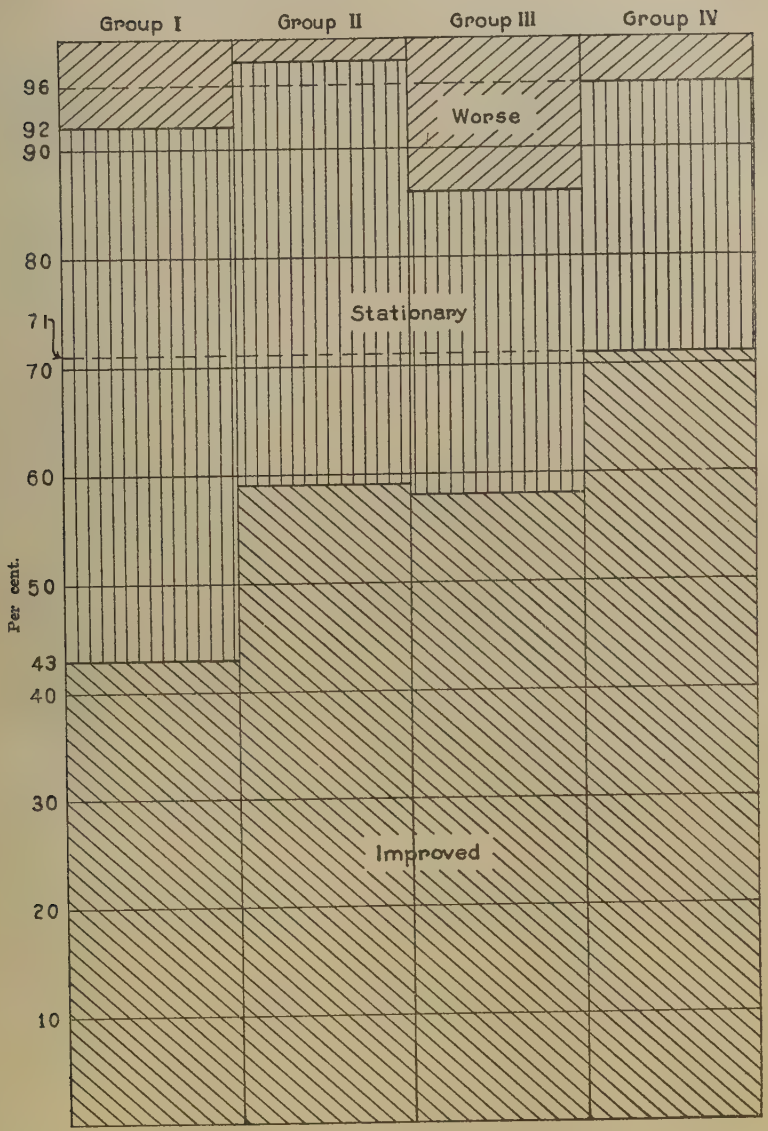

FIG. 2. Progress made by leprosy patients under treatment with creosote.

results obtained are of interest in this connection. In Group II, the maximum amount per week would be 0.6 milliliter, or about 15 grams for the whole six months, in case there were no

absences. In Group III, with the 20 per cent solution in chaulmoogra ethyl ester, 0.6 milliliter of creosote was injected in each average dose of the mixture, 3 cubic centimeters, or at most 30 grams of creosote in the six months. In Group IV with which almost a 10 per cent solution was used, practically one-half of this total amount, 15 grams, would be given.

Here are seen two interesting contrasts; namely, between the same amount of creosote given by different routes and different amounts given by the same route. In Group II, 0.6 gram per week was given by mouth. The chief result, so far as was observed, was apparent stimulation of appetite, increase of weight, and generally improved condition, with at the end better figures for improvement than in the control group. In Group IV the same amount of creosote per week was given intramuscularly. The improvement, betterment of the general condition so noticeable in the second group, was not so marked, but the first figures on improvement of the disease are the best of the series, decidedly better than for Group II, in spite of the fact that the amount of chaulmoogra given was less.

In contrast with the last group is Group III, which received by the same route 1.2 milliliters of creosote per week, together with 1.2 grams of camphor. Here the improvement rate is practically the same as in Group II, and the worse rate is by far the highest of the series. Why this preparation should give poorer results than in Group IV is not clearly apparent. While there may possibly be an element of fortuity, this is believed not determinative. It seems improbable that a 0.6 gram dose of creosote given twice a week is excessive, even by the route used, though we know of no data on the intramuscular use of this drug. It has been suggested to us that the camphor, which is not a drug that one would naturally use in such a disease in considerable dosage over a long period, may be responsible for these less favorable results.

A sidelight on the results of the treatment is given by the effects on the weight of the patients. The changes that have occurred between September, 1922, and January 15, 1923, are shown in Table 9.

Most of the control group, Group I, gained weight, but Group II showed a higher percentage, 78 against 67. Those receiving creosote by injection gave lower percentages than either Group I or Group II. Group III, with the lowest improvement and highest worse rate, reflects these results in the weight changes.

TABLE 9.—*Percentages of patients who showed change in weight.*

Group.	Cases.	Increase.			
		Marked.	Moderate.	Slight.	Total.
I	53	11.3	36.8	18.8	66.9
II	49	10.2	36.8	30.6	77.6
III	43	2.3	18.6	25.6	46.5
IV	49	4.1	36.8	18.4	59.3

Group.	No change.	Decrease.			
		Marked.	Moderate.	Slight.	Total.
I	18.8	1.9	5.7	7.5	15.1
II	10.2	2.0	4.1	6.1	12.2
III	16.3	4.6	23.3	9.3	37.2
IV	24.5	4.1	4.1	8.2	16.4

CONCLUSIONS

From the results of the observations that have been made to date, given herein, the following tentative conclusions may be drawn:

1. Creosote given in small amounts by mouth to lepers serves to stimulate the appetite, resulting in increased weight and increase in the improvement rate in cases under chaulmoogra treatment.

2. Creosote introduced into the muscle causes marked local inflammation, which in some way is to some extent prevented or reduced by camphor.

3. A greater percentage of improvement has been secured with the admixture of a moderate amount of creosote in chaulmoogra ethyl ester.

4. Large amounts of creosote, with the addition of camphor to reduce irritation, give less beneficial results, perhaps because of the injurious effect of the camphor.

5. Creosote preparations apparently cause lepra reaction in a larger number of patients than do the plain preparations, but these reactions are not severe and apparently not harmful.

ACKNOWLEDGMENT

We wish to express our appreciation to Dr. H. W. Wade, acting chief physician of the Culion Leper Colony, at whose suggestion this work was undertaken, and who has assisted us in the analysis of the results and the preparation of this report.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart showing the maximum tolerated dose of creosote in leprosy patients.

2. Chart showing progress made by leprosy patients under treatment with creosote.

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COMPARISON OF NEOTROPICAL AND PALÆOTROPICAL INSECT FAUNÆ

By C. F. Baker

Dean, College of Agriculture, University of the Philippines

Students of certain groups of insects, who have given attention to the faunæ of both the Neotropical and the Palæotropical Regions, have frequently found the highest interest in comparison of the general features of these faunæ as related to groups well represented in both. In certain groups of insects the Neotropics are characterized by great diversity of species in comparatively few distinct generic groups, and in certain groups a high proportion of the genera are common North American or European types. This is well exemplified in the Jassoidea, and in such genera as *Tettigonia, Diabrotica,* etc. On the other hand, in the Palæotropics, while the number of species will probably prove to be even greater (due in part to fragmentation of the territory into innumerable islands), the far greater anatomical diversity in the same groups is very conspicuous, and but few European genera may be represented. Vast numbers of strongly characterized generic groups have been formed under the latter conditions.

Papers recently published by Osborn [1] on the jassoid insects of Brazil and Bolivia clearly illustrate this. Most of the species described are referred to common North American genera and seem to be typical of them. One of these genera, *Idiocerus,* appears to be very homogeneous in structure as it is in America and Europe, whereas the same group in the Far East presents numberless distinct generic types of great diversity in structure. Comparisons of this sort yield some highly interesting data.

In connection with the above-mentioned papers, the following changes in nomenclature are suggested, in as much as they are needed for a list of the Jassoidea of the world, now about ready for publication:

Agallia sara nom. nov. for *A. major* Osb., not *A. major* Leth., 1890.
Idiocerus smithii nom. nov. for *I. fasciatus* Osb., not *I. fasciatus* Fieb., 1868.

[1] Ann. Carnegie Mus. 15[1] (March, 1923).

Scaphoideus boliviensis nom. nov. for *S. bicolor* Osb., not *S. bicolor* Ball, 1909.

Scaphoideus hasemani nom. nov. for *S. punctulatus* Osb., not *S. punctulatus* Mel., 1903.

Thamnotettix picturellus nom. nov. for *T. pictus* Osb., not *T. pictus* Leth., 1875.

Thamnotettix chapadensis nom. nov. for *T. pulchellus* Osb., not *T. pulchellus* Mel., 1907.

Objection might also be raised as to re-use of former names, even though the older combinations represent synonyms, as in the following cases:

Idiocerus rotundifrons Osb., not *I. rotundifrons* Kbm.
Platymetopius lineolatus Osb., not *P. lineolatus* Mots.
Thamnotettix sordidus Osb., not *T. sordidus* Zett.